SYMPOSIUM ON EVOLUTION

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SYMPOSIUM ON EVOLUTION

held at Duquesne University, April 4, 1959,
in commemoration of the centenary of Charles
Darwin's *The Origin of Species*.

Frederick C. Bawden
Andrew G. van Melsen
Gottfried O. Lang
Cyril Vollert, S. J.

Introduction by
Bernard J. Boelen

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PREFACE

The academic phase of the Bicentennial celebrating the founding of Pittsburgh offered us a welcome opportunity to commemorate the centenary of Charles Darwin's work THE ORIGIN OF SPECIES (1859) by means of a Symposium on Evolution. The furious emotional storms which for many decades raged around this scientific work have largely abated and made room for a more sober and critical appraisal of the revolutionary theory propounded by Darwin. It is from such a detached and undramatic academic standpoint that the content of these pages must be viewed.

Evidently, it was not possible to treat the whole subject matter of evolution exhaustively in the single day devoted to the Symposium, for the theory profoundly affects not only biology but a host of other sciences. Rather than limit ourselves to the impact of evolution on a single science, we preferred to offer a selective sampling of its implications in several branches of learning. For this purpose specialists in biology, anthropology, philosophy, and theology were invited to lecture about some of the problems evolution raises in their respective fields. These lectures are preceded by a brief address recalling Darwin and his epoch-making work.

The intrinsic value of the lectures, coupled with their enthusiastic reception by the large audience attending the Symposium, gives rise to the hope that they will be equally welcomed by the public at large.

Henry J. Koren, C.S.Sp.

Duquesne University, Pittsburgh, Pa., April 14, 1959.

A NOTE ON THE LECTURERS

BERNARD J. BOELEN was born in the Netherlands. After studying at the Higher Institute of Philosophy in Louvain, he taught for some time in Holland. Since 1955 he has been at Duquesne University as Professor of Philosophy. He is the author of one book and a number of articles about philosophical questions.

FREDERICK C. BAWDEN, of England, was educated at Cambridge University. Since 1936 he has been attached to the famous Rothamsted Experimental Station for botanical research. In 1958 he was appointed its director. He is the author of two books and more than one hundred articles about viruses.

GOTTFRIED O. LANG was born in Oberammergau, Bavaria. He studied at Brown University, the University of Chicago and Cornell University. Since 1958 he has been Associate Professor of Anthropology at the Catholic University of America in Washington, D.C. He has written ten studies in the area of his specialties and is associate editor of the Anthropological Quarterly.

ANDREW G. VAN MELSEN, of the Netherlands, studied at the University of Utrecht. He is Professor of the Philosophy of Nature and of Science at the Universities of Nijmegen and Groningen. He has published several books and many articles about science and philosophy.

FATHER CYRIL VOLLERT, S.J., of the United States, obtained his Doctorate at the Gregorian University of Rome. He is Dean of the School of Divinity of St. Mary's College, Kansas. Father Vollert has published many studies concerning theological questions, including the relationship of evolution to theology.

INTRODUCTION

DARWIN RECALLED

by

Bernard J. Boelen, Ph.D.

Duquesne University has seized the opportunity of Pittsburgh's bicentennial celebration to sponsor this international symposium on evolution in commemoration of Darwin's *The Origin of Species,* published one hundred years ago. This book immediately caused a scientific and cultural earthquake, and was sold out on the very first day of its publication.

It is my privilege to open this symposium with a brief sketch of Darwin's life and to describe the historical impact of his book *The Origin of Species* on the modern world of thought. I merely want to set the stage and leave the actual discussion of specific problems of evolution to my distinguished colleagues.

Charles Darwin, the son of a successful country doctor, Robert Darwin, was born at Shrewsbury, England, exactly one hundred and fifty years ago, in 1809. He received his elementary education at a boarding school in Shrewsbury. Darwin professed to have found the classical curriculum "incredibly dull," and his main interest at the time was watching the habits of the birds, shooting them, and collecting minerals and insects.

In 1825 his father sent him to the medical school at Edinburgh University. Here, again, he found the lectures "incredibly dull." He hated the abstractions of the lecture hall as much as he loved nature and man. A schoolfellow of his at the time characterizes Darwin as follows. He was "the most genial, warm-hearted, generous, and affectionate of friends; ... his sympathies were with all that was good and true; and ... he had a cordial hatred for everything false, or vile, or cruel, or mean, or dishonourable. He was not only great, but pre-eminently good, and just, and loveable." This authentic picture of Darwin the man is the very opposite of the monkey-like caricature created by the anti-evolutionists.

Darwin, however, did not complete his medical studies. "My father," he says, "perceived that I did not like the thought of being a physician, so he proposed that I should become a clergyman." So he enrolled at Cambridge and graduated three years later. But, once more, he found the studies "incredibly dull," and felt, in fact, that he had completely wasted his time.

Then followed his famous Voyage of the Beagle. In 1831

Darwin was appointed naturalist to the Beagle, a vessel fitted out for a voyage of scientific discoveries in the South Seas. During this voyage, which lasted for almost five years, Darwin took many notes and collected many specimens. These notes and specimens formed the foundation of most of his scientific publications. And it is during this voyage that the idea of the mutability of species and its relevancy for the theory of evolution began to dawn on him.

Back in England again, Darwin immediately started to work upon his findings, and published in 1839 his *Journal of Researches*. The same year he married his cousin, Emma Wedgwood. After living three years in London, the Darwins moved to Down, a country residence in Kent, where Charles remained in ill health for the rest of his life. Yet it is here in Down, that he, in spite of his ailments, accomplished his amazing work and published his extensive and impressive list of scientific studies, including *The Origin of Species*. Darwin died on April 19, 1882, at the age of seventy-one, and was burried in Westminster Abbey near the grave of Newton. His funeral was a national event.

The publication of *The Origin of Species,* a century ago, caused a storm of controversy unequalled in the history of science and thought. *The Origin of Species* was the result of more than twenty years of painstaking research. To be sure, Darwin was inspired by the studies of his grandfather Erasmus Darwin, and by the works of Lamarck, Lyell and Malthus. Charles, however, was the first scientist ever to establish, if not the fact of evolution, then at least its great probability on the basis of his great synthesis of cumulative evidence from morphology, embryology, anatomy, paleontology, geographical distribution, and the like. Having established the theory of evolution on a factual basis, Darwin's next task was to explain its mechanics. The species, he found, are not the result, as it was commonly believed at the time, of special creative acts. He found, instead, that the species have evolved from slight variations in individuals. These variations have been perpetuated in their descendants through the struggle for life. The hereditary characteristics of these variations bring about the survival of the fittest and a natural selection in breeding.

By 1858 Darwin had formulated his theory of evolution,

but did not intend to publish it until he had made further investigations. Circumstances, however, made it imperative for him to present his findings to the scientific world. It so happened that in the summer of 1858 Darwin received a short essay from Alfred Russel Wallace, an English naturalist then working at Ternate in the Dutch East Indies. In this essay, entitled: "On the Tendency of Varieties to Depart Indefinitely from the Original Type," Darwin recognized his own ideas. Friends of Darwin suggested that he send a short abstract of his theory to be read together with Wallace's paper at the meeting of the Linnaean Society in 1858. And within a year, in 1859, Darwin published *The Origin of Species*. The work was shorter than intended, and he deferred the presentation of his huge accumulation of additional facts until 1868, under the title: *The Variation of Plants and Animals under Domestication*.

But is was not only the fact that Darwin had not yet completed his research that made him hesitate to publish his findings. He was fully aware of another fact, namely, that these findings contradicted the orthodoxy of his time. The doctrine of "creationism' 'or "fixism" was the current dogma; it maintained that all species had come into existence by special acts of creation. This fixism was formulated as follows by the Swedish biologist Linnaeus: *"Tot sunt genera et species quot ab initio creatae sunt"* (There are as many genera and species as there have been created from the beginning). Darwin wanted least of all to hurt the feelings of his fellow men and to shatter their religious beliefs. In fact, his discoveries even offended his own personal feelings; as he wrote to his friend Sir Joseph Hooker, "At last gleams of light have come, and I am almost convinced (quite contrary to the opinion I started with) that species are not (it is like confessing a murder) immutable."

Indeed the controversy started immediately after the publication of *The Origin of Species,* at the famous British Association Meeting on June 30, 1860, where Thomas Huxley entered into public debate with the Anglican Bishop Wilburforce. Wilburforce asked the biologist sarcastically whether he was descended from an ape by way of his grandfather or by way of his grandmother. Huxley retorted that he did not

feel ashamed to be descended from an ape, but that he would be very ashamed to be related to a man who misused his great intellectual gifts to disguise the truth.

The emotional and almost hysterical atmosphere of the time is manifested in the titles of books and articles attacking the theory of evolution, such titles as, "The Menace of Darwinism," "The Case against Evolution," "God — or Gorilla," "The Bankruptcy of Evolution," "Essays on Un-Natural History," "The Comedy of Evolution," and "War against Evolution." And to make matters worse, materialists like Haeckel and Voght employed the theory of evolution to attack religion. Haeckel, for instance, stated: "With one stroke Darwin has annihilated the dogma of creation." This arrogant statement is as one-sided as the literal interpretation of Book Genesis in the sense of creationism. For the rejection of creation cannot be found anywhere in the premises of biological evolution, but it is implied in the dogmatic materialism of Haeckel. The controversy was not between the theory of evolution and the theory of creation, but between evolutionism, or evolution without creation on the one hand, and creationism, or creation without evolution on the other. And evidently they could not have any ground in common. Evolution was wrongly identified with evolutionism and creation with creationism, and, of course, these extreme positions appeared to be irreconcilable.

This situation reminds us of the times of Galileo Galilei, the sixteenth and seventeenth centuries. Galileo's *Dialogues on the Two Main Systems of the World* was condemned because it subverted the geocentric universe on which some theological opinions of the time were based. Man's dwelling place was no longer the center of the universe. A colleague of Galileo refused even "to look through Galileo's telescope for fear of finding that Aristotle's physics were wrong." Thus Darwin's *The Origin of Species* and his *The Descent of Man* subverted the anthropocentric universe of the nineteenth century. Man in his entirety was no longer honored by an act of special creation that set him apart from the animal kingdom. At least in so far as his body was concerned, he seemed to be the end-product of a long evolution, and had to call some anthropoid apes his immediate ancestors. This, of course, was

so shocking to the mentality of the creationist, that at first he refused to look through the telescope too, he refused to face the facts, and often even refused to be scientific for fear of coming into contact with "the monkey theory." This ostrich-policy still accounts, in our opinion, for the remnants of anti-intellectualism among some secretarian groups.

Yet, we have to appreciate the bitterness of the controversy. Indeed, the truth or falseness of the theory of evolution, its acceptance or rejection is no trifling matter. It affects profoundly our philosophy of life, and has its repercussions in practically every domain of knowledge. At first, the controversy was mainly concerned with the *fact* of evolution. Since the first world war the storm has subsided, and the emphasis of the discussions is more and more on the *way* and the *extent* of evolution than on its fact. The growing acceptance of the fact of evolution, however, has not solved its problems. On the contrary, the problems have been increasing in number and complexity. The relative quiet, however, of the past decades has created a favorable climate for undisturbed research and clear thinking on the problems of evolution.

This research has radically changed our understanding of the universe we live in. We no longer believe that man and his world are about 6000 years old (1959 years plus the family tree of Christ plus the six days of creation). At the present day most scientists believe that man is descended, somatically, from the higher primates at least some 500,000 years ago. Life has existed on earth for more than a billion years, and the inorganic universe must be at least some 5 billion years old.

However, the very mechanics of the evolution of the universe, of the first beginnings of life on earth, and of the original descent of man are still shrouded in mystery. Moreover, has evolution come to a dead stop in man, or does man unceasingly evolve in his higher, his cultural, moral and social aspects? Here we think, for instance, of "the creative evolution" of Bergson, "the dialectical materialism" of Marx, "the superman" of Nietzsche, "the socio-cultural dynamics" of Sorokin, "the tele-finalism" of Lecomte du Noüy and "the noosphere" of Teilhard de Chardin.

Whatever we may think of these theories and views, at the

centennial of Darwin's *The Origin of Species* one thing stands out—namely, that this controversial book is no longer a menace, but has become a challenge. Today's Symposium was conceived to meet this challenge.

EVOLUTION AND VIRUSES

by

Frederick C. Bawden, M.A., F.R.S.

Introduction

The titles of the other contributions to this symposium make mine seem rather narrow and unimaginative. However, so far from being embarrassed by the insignificance of my subject, I am more so by its scope. This fact could, I suppose, be taken to prove that I am one of those scientists who are so often, and often so wrongly, condemned as narrow-minded specialists, but I hope for a more charitable interpretation. The one I suggest, rather than lack of imagination, is that I prefer to deal with a subject in which at least some conclusions can be subject to test. My outlook and experience as an experimental biologist make me a sceptic, reluctant to accept anything on faith and always suspicious of conclusions that cannot be supported by factual evidence. Not that science is only a collection of facts. Factfinding is the determinant part, but to be aesthetically satisfying the facts need to be fitted into some general concept. To be useful, however, scientific theories must be more than mental exercises; not only must they fit all known facts but they must be susceptible to further tests of their validity. I appreciate how valuable are speculation and imagination, and I fully understand the pleasure and satisfaction to be derived from logical reasoning, but a generalization or theory that cannot be checked remains for me in the general category of fairy stories or detective fiction. Facts are needed too, not only as a brake on speculation, but because unaided imagination, however vivid, is quite unable to produce such remarkable phenomena as are readily uncovered by biological experiment or observation.

We celebrate today one of the greatest generalizations of all times, the theory of evolution by natural selection operating on mixed populations. It was open to objective test in all biological systems, and the measure of its success is that it stands now even more firmly established than when Darwin published *The Origin of Species* one hundred years ago. This is no accident. The theory was not put forward as a hasty deduction or an inspired guess; it was a conclusion forced on Darwin, an admirably cautious and critical biologist, from the wealth of factual evidence he had so tirelessly gathered. He already had the idea when in 1837 he returned from his travels in H.M.S. Beagle, but only after 5 years' work — "patiently

accumulating and reflecting on all sorts of facts which could possibly have any bearing on it" — as he tells us in the Introduction to *The Origin*, did he even allow himself to speculate, and he then spent another 16 years checking facts before publishing. Even then he did so only because Wallace had arrived at similar general conclusions, and he apologises for the inadequacies and imperfections of his abstract, which, he thought, really needed "two or three more years to complete". What a man!

In Darwin's time the existence of viruses was not even realized, but the general principles he annunciated hold no less with them than with the higher organisms he studied. Indeed, I am happy to be talking on systems that can, perhaps, produce evidence for variation and the effects of selection on variants more readily and rapidly than any other. There is a simple reason for this, namely that viruses achieve population figures far greater than those of any organisms. In this context it is enough to say that a single bacterium may contain some hundreds of virus particles, and a single tobacco leaf fully infected with tobacco mosaic virus will contain thousands of millions.

The non-committal conjunction "and" in the title of my contribution makes my subject embarrassingly wide. It commits me to discuss, not only the evolution of viruses themselves, both how they are changing now and what they have evolved from, but also their effects on the evolution of other biological systems. Then, too, though I do not think that viruses are relevant to the fascinating problem of how life originated on earth. Other people do, so I must at least mention it. Almost every symposium on the origin of life has papers from virus workers, and the most recent one of which I know, at Moscow in 1957, had at least four. To understand how this comes about, and to see that the logical reasoning is not too firmly based, we had better take a little time to describe the discovery of viruses and to summarize present knowledge about them.

Definition of a Virus

The discovery of viruses dates from 1892, when Ivanowski showed that the cause of tobacco mosaic virus passed through a bacteria-proof filter and that a seemingly sterile filtrate

could be infective. The germ theory of disease was then in its hey-day and it was confidently thought that, for each infectious disease, there would be found a micro-organism identifiable under the microscope and probably able to grow on artificial media. However, in the next few years, several diseases were found that resembled tobacco mosaic in that their causes were invisible, passed through fine filters and would not multiply, as most bacteria do, on nutrient media. Until then the word virus had been used more or less indiscriminately for all kinds of germs, but now it became increasingly restricted to these anomalous entities made all the more fascinating because of the fact that their nature was shrouded in mystery. Even today, we can define a virus only in negative terms, as an invisible germ that multiplies only in living cells; or, to say the same thing in longer words and make it sound more impressive, an obligately parasitic pathogen too small to be resolved by microscopes using visible light.

Primitive or Advanced Stages in Evolution?

Viruses show two features widely considered to be specific to organisms; they multiply and vary, for offspring sometimes differ from their parents. There is, then, little surprising in the fact that most people were content to regard them as essentially similar to bacteria, different in size and complexity rather than in any more fundamental manner. Perhaps most conflict for some time was between workers who regarded viruses as retrograde organisms, evolved from larger ones by losing characters for which as obligate parasites they had no use, and those who regarded them as upward stages in the evolution of organisms from simpler systems. It was the second view that brought viruses into discussions about the origin of life: for if viruses were primitive organisms, might they not resemble the form in which "life" started? This, overlooking as it did the fact that viruses will not multiply even in rich nutrient media, was not very realistic, for ability to live as a saprophyte must surely have been the prime requirement of the first forms of life.

There was a further conflict of opinion about the nature of viruses, between the majority who saw them as organisms, in whichever direction they might be evolving, and the minority, mainly from those working with tobacco mosaic virus, who

considered them fundamentally different from even the simplest organism. This conflict was resolved in favour of the minority in the 1930's when tobacco mosaic and several other viruses were isolated and characterized as liquid crystalline or crystalline nucleoproteins. At the time it was their ability to crystallize that excited most attention, but this was mainly important in showing a uniformity of particle size that would be unusual with organisms and seems incompatible with multiplication by binary fission. It also had the great practical value of making the virus preparations amenable to study by the technique of X-ray crystallography, which showed that the individual virus particles were composed of many similarly sized units grouped in a fixed and regular manner that contrasts strikingly with the fluidity and variability of structure in cells. In their manner of structure and in their chemical simplicity, consisting of only two major components, protein and nucleic acid, they clearly resembled macromolecules, single components of organisms, rather than whole organisms.

Viruses then seemed to be self-replicating nucleoproteins, and the temptation to introduce these apparently simple reproductive systems into discussions on the origin of life was irresistible to some people, although as always it meant neglecting the fact they multiply only in living cells. The temptation was increased by the fact that aminoacids, the component parts of proteins, can be made by the action of electrical discharges on a reducing atmosphere containing methane, ammonia, water and hydrogen, the conditions often assumed to have existed when life originated. If aminoacids, why should not these condense into proteins and become self-perpetuating systems? Perhaps, but recent work shows that this has little relevance to viruses. The nucleoprotein particles, which for 20 years seemed to be the minimal infective unit and the replicating system, have now lost this position. Tobacco mosaic virus will suffer the indignity of being taken apart and put together again, and this fact has allowed the roles of its two components to be tested. It is now clear that the protein as such does not reproduce itself; virus fragments that consist predominantly, and possibly exclusively, of nucleic acid can be infective. The infections they initiate produce not only more nucleic acid but complete virus particles containing their

usual amounts of both protein and nucleic acid. Hence nucleic acid seems to be the replicating part, able both to reproduce itself in the right environment and to initiate the synthesis of a specific protein to go with it. This is a still simpler replicating system than virus particles, so have we here the model for the first forms? Again it seems improbable. Not only do electric discharges in the conditions that produce aminoacids fail to produce purines and pyrimidines, the raw materials of nucleic acid, but the nucleic acid of tobacco mosaic virus is so unstable that even in the benign atmosphere of cold distilled water it soon inactivates. Exposure to almost any other environment speeds inactivation and the chances of such a nucleic acid surviving in the inhospitable conditions usually postulated for the pre-biotic era would seem to have been slim indeed.

It is probably as idle to look at present biological systems for hints about the origin of life as it would be to examine a nuclear-powered submarine to find the first means whereby man crossed the seas. The more efficient systems oust the less efficient, and in time they do so completely. The fact that all reproductive systems seem now to consist of nucleic acids associated with proteins probably goes far to explain the success of Darwin's generalization. But is does not necessarily mean the first systems were of this type; it may mean only that nucleoproteins are the most efficient and adaptable reproduction systems that have yet evolved.

Intact tobacco mosaic virus is one of the most stable of nucleoproteins. Whatever other part the protein may play in the activities of the virus, it is clearly indispensable now simply to protect the nucleic acid from being destroyed. Can we infer from this that proteins came first? I think not. The first nucleic acids would have had to survive unprotected, but they may well have lost their sturdy independence during continued association with proteins, perhaps substituting other characters for the stability they no longer required. The fact that viruses are associations of two highly complex and mutually dependent substances fits better with the idea that they are relatively late products of evolution rather than primitive forms.

The Origin of Viruses

Our immediate subject is the origin of viruses rather than

the origin of life, and for this the wealth rather than the poverty of possibilities is what sets insoluble problems. Certainly there is no need to assume that all have developed from pathogenic organisms, which have gradually lost their form and function. As we have already noted, all biological systems contain nucleic acids and proteins; nothing that has yet been found about the constitution of plant viruses sets them apart from the nucleic acids and proteins of "normal" cells. Although larger than most "normal" nucleoproteins, tobacco mosaic virus, for example, seems to contain the same amino-acids as occur in other, non-pathogenic, proteins. Similarly, the only purines and pyrimidines yet identified also occur in other nucleic acids of the ribose type. Maybe there are quantitatively minor components still to be discovered, and it would be vain to pretend that knowledge about the components of nucleic acid is complete, but it does seem possible that the differences between viruses and other nucleoproteins lie in the way their component units are put together rather than in any unique components.

Normal cells have nucleic acids of two kinds, those with the sugar ribose and those with deoxyribose, and viruses also fall into two types, one containing ribose and the other deoxyribose nucleic acid. The old disagreement, seemingly irreconcilable, between those who called viruses organisms and those who called them molecules, posed an unreal antithesis. Both sides overlooked the fact that there are many cellular components other than viruses that do not fall neatly into either category; chromosomes and cytoplasmic nucleoproteins are examples containing the two types of nucleic acid and of systems that also resemble viruses in seeming to reproduce themselves in the right environments. These provide the closest analogies for viruses and it is from such complex cellular components that is it most reasonable to assume that viruses have evolved.

There is nothing novel in this idea. Muller suggested nearly 40 years ago that viruses were genes that had become freed from the confines of chromosomes and were acting independently of other genes. Now, when there is information about the chemical composition of viruses, his insight in relating them to genetical systems rather than to pathogenic micro-

organisms is clear, but it is also clear that, if a gene is defined as something determining a single inherited factor, the viruses are more complex than single genes for each contains many features that are inherited independently of one another.

Viruses, of course, differ from other nucleoproteins or we would not distinguish them and place them in a separate category. There are, though, only two distinguishing features common to all viruses; these are ability to cause disease and be transmitted from organism to organism. It is true that some viruses have a characteristic morphology and differ in other ways from non-infective nucleoproteins, but this is no more a barrier to assuming similar ancestries than the differences between giraffes and other mammals preclude their evolution from a common stock. The viruses now most studied are those that cause most obvious effects and are most easily transmitted, and these are unlikely to have achieved their present eminence and success without many adaptations.

It is now evident what a precise piece of mechanism is the bacteriophage's tail and what it does to get the virus from one bacterial cell to another; such a mechanism obviously did not arrive out of the blue as a single change in a "normal" non-infective nucleoprotein. The particles that first behaved like a virus and managed to escape from one cell and enter another, were almost certainly less well equipped and found the transfer much more difficult than do current bacteriophages. There seems no reason why viruses should not still be originating from non-pathogenic nucleoproteins, but I think it would be wrong to expect any new ones to behave like those currently most studied. They are likely much more to resemble "normal" nucleoproteins, and so be more difficult to isolate and characterize; they are also less likely to be easily transmitted from organism to organism or cell to cell. Indeed, I would expect newly originated viruses to cause conditions resembling those now described as "non-transmissible" tumours of animals and "non-infectious" chloroses of plants. That is to say, normal components become pathogenic, but not yet adapted for transmission. In considering the origin of viruses, it is relevant to stress that only a few have been isolated and studied in any detail. There are many reasons for this, but

one may be that some are so like "normal" cell components that they cannot be readily separated from them.

Changes in Transmissibility

Few viruses have developed mechanisms comparable to those that enable bacteriophages to move unaided from one organism to another. Although some, such as those causing the common cold and influenza, are air-borne and spread from infected to uninfected people without the help of another organism, most viruses of higher animals and plants depend for their spread on insects or other kinds of arthropods. Active insects that feed on many different individuals during their lives are obviously excellent vehicles for moving entities from one individual to another. Indeed, some viruses, such as tobacco mosaic that now seem not to be insect-transmitted, may have been so initially, but later developed other methods of spread that have largely superseded transmission by insects. What determines the ability of a given virus to be transmitted by a given species of arthropod is not known, but it is clear that no enormous changes in virus particles may be needed to render them transmissible. There have been several examples of viruses gaining or losing the ability to be transmitted by a given species of insect while they have been studied experimentally, and while retaining many of their other properties. There is no reason to think that these changes ("mutations") happen only during experimental work. On the contrary, there is strong presumptive evidence that it has happened to several viruses before anyone started to experiment with them.

Potato virus Y, one of the most important potato viruses, occurs in a range of forms distinguishable by the type and severity of symptoms they cause in different potato varieties and other plants such as tobacco. The strains common in tobacco plants and in newly infected potato plants are usually all readily transmitted by *Myzus persicae* and some other aphids, but those in some old potato varieties are not. As strains of virus Y are among those that have changed their transmissibility during experiments, the difference can be readily explained. A potato plant infected with virus Y sets infected tubers which will in turn grow into infected plants, and so on, indefinitely perpetuating the virus as long as the

clone continues in existence. Thus the future of a virus in such a vegetatively propagated plant is secure, without need to be transmitted to more plants.

The position is very different with plants raised annually from true seeds. Few viruses are seed-transmitted, and so most seedlings start life virus-free even though their parents were infected. Hence, to be common in annual plants, viruses must have an efficient method of transmission, and selection operates continually in favour of forms that are readily transmitted. Similarly, a potato plant newly infected is likely to have been infected by a readily transmissible form. But there is no continuous selection inside this plant favouring the survival of aphid-transmitted forms. Should other variants arise that are better suited than the initial strain to survive, perhaps better able to invade and permeate the tubers, then these will predominate and the original form will disappear. We can thus picture the old potato varieties, initially infected by aphid-transmitted strains of virus Y, now containing different strains, strains that have lost this ability, which has no survival value in vegetatively propagated plants, and strains that would have originated only to disappear on the death of their host plant had the plant not been vegetatively propagated.

If, then, accepted viruses can lose and regain transmissibility it seems reasonable to think that "normal" nucleoproteins could also sometimes undergo analogous changes and achieve one character of a virus by becoming transmissible. However, it must be stressed that there is no substantial evidence of viruses arising endogenously from normal cell components. On occasions there has seemed to be some evidence, but when critically examined it has proved valueless. One example, often featured in arguments for the endogenous origins of viruses, is potato paracrinkle virus, which is present in every plant of the potato variety King Edward, one of the most widely grown varieties in the United Kingdom. It does this variety little or no harm, but cripples many others. However, it never occurs in these other varieties naturally, and its effects on them are known only from experimental transmissions. As paracrinkle virus seemed to have no natural method of spread, how could it have infected the first King Edward plant and so permeated the whole variety? For a time, it was plausible to think that

it might be a "normal" component of this variety, a metabolic product of its intrinsic metabolism that becomes a virus in other plants.

However, recent work suggests another explanation, again based on the idea that viruses can lose and gain transmissibility and that they tend to lose it when it is not continually selected for. Although paracrinkle virus has not been found elsewhere or to have any insect that transmits it, other viruses have been found that resemble it very closely. One of these is common in carnation plants; this shares antigens with paracrinkle virus, indicating close relationship for it reflects common structures in the proteins of the two and is a feature of related virus strains, but the carnation virus is readily transmitted by aphids. Another virus serologically related to both paracrinkle and the carnation virus has been found in some other potato varieties, but this one again is not aphid-transmitted. Hence, it seems reasonable to assume one aphid-transmitted ancestor for all three, but that only the carnation one now retains this property, which has been lost during the years the others have had their survival assured simply by the vegetative propagation of their hosts, without any selection for aphid-transmissibility. The other potato virus, like paracrinkle in King Edward, causes no obvious symptoms in the varieties all stocks of which are infected; this was an essential requirement, because had it produced symptoms in a crop like the potato, a virus unable to spread from plant to plant would long ago have been eliminated by growers destroying obviously diseased plants.

Lysogenic bacteria also seemed for a time to offer evidence for the endogenous origin of viruses in cells. Such bacteria mostly grow normally, but a proportion produce bacteriophages and lyse. By appropriate stimuli, such as exposure to ultraviolet radiation, they all will. That lysogenic bacteria carry the potentialities of producing viruses is evident enough, but is now seems probable that their ancestors contracted these potentialities as a result of infection rather than that the potentialities were originally intrinsic to their constitution. Bacterial viruses can have two phases to their existence. First, there is the long-known one whereby they appear as extracellular units, the typical bacteriophages that dissolve their

host cells and infect other cells unaided. These are the complex particles of protein and nucleic acid. Only the nucleic acid seems to enter newly infected cells; usually the nucleic acid not only multiplies but also produces the protein to go with it, and the classical sequence of infection and lysis with the liberation of new bacteriophage ensues. But sometimes the nucleic acid seems to become associated with the genetical mechanism of the host bacteria in a manner that allows it to survive without producing the characteristic bacteriophage protein. This is the condition in lysogenic bacteria: bacteria that are not already lysogenic sometimes become so by infections with appropriate bacteriophages, so it again seems more reasonable to assume that natural lysogeny also results from past infections rather than from an *ab initio* creation in the lysogenic bacterium. Similar conditions to those in lysogenic bacteria have yet to be identified with certainty in other organisms, though the ability of some seemingly normal insects to produce virulent viruses when subjected to some stimuli could be a similar phenomenon.

We are thus in a rather odd position in theorising about the origins of virus. It is clear that every living cell has the potentialities of producing viruses for they all can make nucleic acids and proteins, which are the basic materials of viruses. It also seems that the main requirement of any nucleic acids and proteins to acquire the distinguishing features of viruses is to become transmissible, that is to be able to survive extracellularly for at least the time needed to spread from cell to cell and become incorporated into other cells. We have, too, in some organisms the apparent phenomenon of viruses suddenly occurring when cells are subjected to appropriate stimuli, but all these are adequately explained as consequences of previous infections. Although we have the pointers to the possibilities of any cell producing something acting as a virus, either in itself or in some other organism, we lack any conclusive evidence to show that any of the now recognized viruses has, in fact, derived from non-pathogenic or non-transmissible nucleic acids.

Variation and Selection

Whatever were the origins of the agents we now call viruses, their variability and adaptability are so great that no

long spell is needed for them to change their behaviour considerably. Passage through a new host, or exposing an old host to a new environment, is often all that is needed to change some property strikingly. The apparent purposefulness of the adaptation to a form better suited to the new host or to the new environment may seem to suggest that the new treatment is actually causing the change, but for this there is no evidence. All the phenomena are adequately explained by postulating selection operating on random-variants. Some of the random variations probably reflect changes equivalent to mutations, but not all need be. There is much evidence that some of the offspring that are produced when two strains are multiplying together in one cell combine characters that previously belonged to either one or other of the parent strains, so that recombination of existing genetic factors could also be a potent force in variability. However, with the immense populations of virus particles that occur in infected cells, only a small mutation rate would be needed to produce many variants on which natural selection can begin to operate. And selection is likely to operate quickly, for strains of one virus compete strongly with one another. With plant viruses the competition is such that when a cell is fully infected with one strain, other strains are precluded from multiplying in it. Hence, should a variant occur that multiplies and moves from cell to cell a little faster than the parent type, it will not only have this initial advantage, but by entering cells sooner it will also prevent the parent type from coming later and interfering with it. All that is needed, for example, to get strains better adapted than the type strains of tobacco mosaic virus for existence in plants at 37°, is to infect plants with the type strains and put them at 37° for a day, after which the predominating strains at many infected centres are already variants that multiply and move more readily at the higher temperature. Most variants of viruses have, of course, been found in the course of experiments designed specifically to identify them, but there is abundant evidence for their occurrence in the wild. Variants differing from one another in almost every property for which tests have been devised have been encountered. The most common type of variation to be described, probably only because it is the easiest to

identify, is in pathogenicity, either in the type and severity of symptom caused or in the host range, but other properties vary no less. Changes in transmissibility have already been mentioned, but resistance to heat or other inactivating treatments can vary, as can antigenic and aminoacid constitutions, both in strains isolated experimentally and those found in naturally infected plants.

Some naturally occurring variants of tobacco mosaic virus differ greatly from one another in constitution and general properties. As these strains were usually found in taxonomically unrelated plants, their differences seemed to entail long periods of evolution in separation from one another. However, a strain from leguminous plants with which I have worked changes its constitution greatly on immediate transfer from leguminous plants to tobacco. In tobacco plants it closely resembles the type strain of tobacco mosaic virus, except in its ability to infect leguminous plants systemically; this it does not do very readily, but when it does it changes to a form that contains aminoacids not present in the tobacco form and that is no more like the type strain than others that are thought to have reached their great differences only after they had evolved for a long time along different lines. The fact that large reversible changes can happen quickly is not evidence that only one genetic factor is involved. The change from the form that invades tobacco to the one that invades beans need happen at only one out of hundreds of infection sites, at each of which many thousands of particles are produced. When one appears with the immense advantage over the others of being able to invade its new host systemically, it will escape from them and multiply unhampered by competitors. The appearance is created of the whole stock of virus changing its character, but this is apparent rather than real. Most of the initial infecting particles multiplied unchanged, and to produce the one with the form needed to infect the new host systemically may have involved many separate genetic changes, mutations, recombinations, or both, during the local multiplication of the original inoculum.

The differences so far noted between the constitution of different strains of viruses lie in the protein fraction, and are detectable by amino-acid analyses or by serological tests.

However, these differences are clearly not the primary genetic changes; the specificity and genetic continuity lie in the nucleic acid, for infections with the nucleic acid moeity alone give the same results as infections by whole virus. Indeed, when infections are made with nucleoprotein made by combining nucleic acid from one strain of tobacco mosaic virus with protein from another, they produce new virus particles with protein characteristic of particles from which the nucleic acid came. Hence the protein seems not to be concerned with directing the synthesis of the virus particles, and changes in it reflect earlier changes in the nucleic acid. Whether genetic changes are simply rearrangements of the four purines and pyrimidines yet identified in the nucleic acid of tobacco mosaic virus, or whether there are other constitutional changes that affect its genetic and chemical behaviour, only time will tell.

Effects on the Evolution of Organisms

It is easy to show in a very short time with bacterial viruses the whole Darwinian philosophy of natural selection operating on variants and perpetuating those forms best suited to survive in a new environment. When a bacterial culture is infected with an appropriate bacteriophage, the culture will become water-clear as the virus multiplies and spreads rapidly through it, apparently killing all the cells. After a while, though, bacterial growth usually starts again, and ultimately there is established a culture of cells immune from that bacteriophage. The new culture derives from variants possessing the property, previously of little value but all important in the new environment, of resisting the bacteriophage.

A dramatic effect of this type is, of course, demonstrable only with the closed system of an experimental culture in a test-tube, and cannot be taken to represent what happens in less artificial systems, where a bacteriophage will rarely be able to reach the whole of a susceptible population. For example, many samples of soil contain bacteriophages and bacteria susceptible to them, showing that resistance to this bacteriophage is not a prime requirement for the bacterium to survive in that soil. However, there are probably many occasions where such resistance has determined survival at least in restricted localities, and the ability to vary in this

property has probably often influenced the direction of evolution in many kinds of organisms.

Whether virus diseases have ever been responsible for destroying whole lines of susceptible organisms is unknown and is perhaps improbable, because an extremely efficient method of spread would be needed to infect every individual in a population not artificially restricted. An example of what can happen has recently been provided in the United Kingdom by myxomatosis in rabbits. In places where rabbits were plentiful and living in burrows, this newly introduced virus spread rapidly through the populations and eliminated them. In such areas, secondary evolutionary effects are now to be seen in a changing flora, with species previously grazed heavily by rabbits becoming more prominent than previously. In other areas, where rabbits were less abundant and not all in burrows, some escaped, and these are now beginning to re-establish populations in some areas cleared by the disease. It would be idle, and rash, to forecast what will now happen, when we only have to wait to see the event, but there are several possibilities. One is that the virus itself will disappear because the population of susceptible hosts is too small to ensure its survival. Another is that it will produce a variant less virulent than itself, which could lead to an immune population of rabbits by providing a natural vaccine. A third is that the rabbits themselves, although not quite as prolific as bacteria and so less likely to do so, will produce resistant variants. Or, perhaps most likely, there will be a lasting effect on the rabbit population, with myxomatosis virus always about, although never very apparent when rabbit populations are low, but flaring up wherever and whenever large populations occur in burrows.

These kind of effects are not peculiar to viruses, but general to all kinds of pathogens that cause lethal diseases. There is a more subtle way in which viruses may influence the evolution of organisms. It is by adding to their genetical potentialities. That this happens in bacteria is established. We have already instanced lysogeny, but in addition to this, infections with bacteriophages can also carry other genetic factors from one bacterium to another. There is no evidence for any comparable occurrences in higher organisms, but there is no

reason to assume bacteria are unique and the potentialities are obvious. By gaining the property of transmissibility, a nucleic acid or nucleoprotein in one species has the opportunity of being transferred to another. Now we recognize this kind of transfer only with viruses, but there seems no *a priori* need for transmissibility always to be linked with pathogenicity. Indeed, many of the agents we recognize as viruses are not pathogenic in all the species they can infect, but they have to be pathogenic in something for us to recognize that they are transmissible. With the development of better techniques of testing for specific substances, we may expect to end this *impasse*. Then, viruses may emerge as being only the pathogenic individuals among a rich collection of transmissible factors, some of which may have been more beneficial to the organisms they have invaded than their pathogenic relatives have been harmful. Variation is a random process; selection is the directional one, and it is unlikely that selection of infective nucleoproteins has been solely for pathogenicity.

HUMAN ORGANIC EVOLUTION: FACT OR FANCY?

by

Gottfried O. Lang, Ph.D.

Introduction

There is a story, quoted by Dobzansky,[1] that when Darwin's theory of man's non-human ancestry became known, a Lady cried: "Descended from the apes! My dear, we will hope that is not true. But if it is, let us pray that it may not become generally known." As it was, the theory that Charles Darwin so ably argued, has in fact become not only widely known, but also widely accepted. Nevertheless, to many it still is either repugnant, or undesirable on religious grounds, to seriously consider the theory proposed by Darwin a hundred years ago. Even now after it has been refined in the various branches of Biology and in Anthropology, primarily because of relatively recent advances in the life sciences it still presents problems to many. But as Father de Chardin[2] observed, the idea of ancient fossilized ancestry of man ... "represents a surprisingly recent conquest of the modern mind. Today no one any longer questions it, or even wonders at it." But of course, there are exceptions, and the oft-mentioned Scopes monkey trial of Tennessee attests to the fact that emotion can still run high when discussing the evolution of species in general, and of man in particular.

This paper will attempt to avoid the problem of religion and evolution, not because this particular question is not important, but for present purposes it is not relevant. The assignment given, as it is interpreted here, is to look at the evidence for evolution as we know it today, a hundred years since Darwin published *The Origin of Species*.[3] The first task then will be to examine the fact that there are many organic species closely related to man, some of which are also to be found in the fossil records which are often intermediate between the various contemporary forms. After looking at this kind of evidence, it will be convenient to look at some of the ways in which the diversity of specific forms has been explained in the past and see how these explanations compare

[1] Theodosius Dobzhansky, *Evolution, Genetics, and Man,* New York, 1955, p. 319.

[2] Pierre Teilhard de Chardin, "The Idea of Fossil Man," *Anthropology Today* (A. L. Kroeber, ed.), Chicago, 1953, p. 93.

[3] *On the Origin of Species by Means of Natural Selection,* 1859. Reprint of the first edition, New York, 1951.

with those current today. Finally, it might be worth while to speculate not so much on the "goodness" or "fit" of evolutionary theory as such, but rather on whether the theory, in the absence of any other, fulfills the requirements of scientific theories in general.

The Fossil Record

Anthropology was relatively slower than the other life sciences in accepting the proposition that man's ancestor did not look like modern man. In fact, some of the fossil finds in the latter part of the last century (Cro-Magnon, 1868) seemed to contradict all that Darwin had said, and suggested that man had always been as he now is. But two major events in human paleontology changed this rather narrow conception: First, there was the discovery in the Neanderthal cave in 1856 of a scull cap, which did not immediately influence the thinking of the times while later and similar finds had a tremendous impact upon current thought. Second, the discovery of a primitive fossil in 1891 by the Dutch physician Dubois in Java, in a stratigraphic level with faunal assemblages which seemed to relate it to the middle pleistocene. Since this time, many more fossils have been found and the great antiquity of man which seemed at first highly improbable, has taken on more and more credibility. It may be well then to consider the fossil evidence which has so profoundly contributed to this change, not chronologically as it accumulated through the past sixty years or so, but as current taxonomists arrange the evidence.[4]

One may begin with an examination of the fossilized remains of man's nearest relative morphologically speaking, the anthropoid apes. These appear in Pliocene and Miocene deposits over wide areas of the old world, from sites in Europe, India, and Africa. The two fossils from Siwalik deposits in India (*Bramapithecus* and *Ramapithecus*) seem to approximate more

[4] The fossil evidence has been summarized and carefully presented by Clark, himself an anthropopaleontologist, whose descriptions and interpretations of the taxonomic status of fossil remains have been used here. His work, *The Fossil Evidence for Human Evolution,* Chicago, 1955, contains also a detailed bibliography of the original sources from which conclusions are drawn.

closely the hominidae (man's ancestral family) than the pongidae (ancestral to apes) in such characteristics as the construction of the molars, and other dental traits. These fossils suggest a transitional stage away from the pongidoid stem. But other fossil evidence from India is too scanty to warrant further speculation about a branching off in a hominid direction. From Europe came a femur and shaft of a humerus of *Dryopithecus* and parts of a limb skeleton of *Pliopithecus*. These, and similar and more complete finds from East Africa (*Proconsul* and *Limnopithecus*), suggest that they had not yet developed towards the extreme features of the modern apes by virtue of being more slender and straight than would be expected of an ape-like trend. Some very recent *Pliopithecus* finds from Middle Pliocene times in Austria suggest even certain cercopithecoid affinities. In general these fossils show more affinities with the quadruped cercopithecoid monkeys of today than with the brachiating apes according to Clark.[5] These finds suggest a divergence of pongidae and hominidae which may be placed at early or middle Miocene times.

The importance of these finds is enhanced by considering some functional aspects. It stands to reason that perhaps at this time, at least some of the common ancestors of man began to stay fairly close to the ground, as is evidenced by the very large East African ape (*Proconsul major* whose size is equivalent to modern gorilla) which at the most could only braciate in lower and sturdy branches of trees and probably was also moving about on the ground a great deal. But the limb bones for this fossil have not been found, which, when found, will shed further light on this problem. An important consideration is the environment of East Africa at that time, which consisted of only slightly wooded valleys (as evidenced by the faunal assemblages in Kenya) separated by savannas which could have provided the stimulus for development towards ground living forms. As Clark[6] points out, the attempt was not to *abandon* arboreal life, but to retain it, that is those who tried to go from one shrinking woodland to another could do so only if they were able to move effectively on ground.

Whether this group of fossils is ancestral to man and to

[5] *Op. cit.*, p. 169.
[6] *Op. cit.*, p. 170.

what degree, has to await further evidence. But what is extant so far, strongly suggests that this period is critical, and perhaps the recent Tuscany finds in Italy (not yet described in the scientific literature) will greatly aid in deciphering this riddle.

As one leaves the pongidoid ancestry, one does not at the same time leave the very important continent of Africa. Since 1925 fossils have been found which may well turn out to be critical in understanding the development of organic forms which lead to modern man. Professor R. A. Dart from Johannesberg, South Africa, found a skull at Taung which he called *Australopithecus,* or South African Man-Ape.[6a] Since that time, Broom, Robinson and their collaborators have found enough additional fragments which represent at least sixty-five individuals and an extremely large number of teeth from possibly another hundred individuals. These fossils go under several generic names, but recent opinion[7] suggests that we are dealing with one genus, and perhaps two species. The important feature of the South African fossils are that they are widespread in the region and that they are so abundant; unfortunately they have not all been described yet.

The dating for this area is not very secure, because it is based upon faunal assemblages which have been correlated with European assemblages of mid-pliocene age. On the other hand, the fact is that mammals which became extinct in Europe by Pleistocene times seem to have lasted longer in parts of Africa. Hence great caution has to be exercised on this account. Most authorities seem to place the fossil materials in the early part of the lower Pleistocene. One thing seems to be certain from the faunal assemblage, that the environment was not unlike it is today, i.e., tended towards aridity, and hence was not conducive to arboreal life.

The *Australopithecine* fossils as a group, though showing great variability in size, (due in part to the fact that some skulls are from immature individuals), show some striking hominid features, but also some important simian features.

[6a] Raymond A. Dart, "The Minimal Bone-Breccia Content of Magapanskat and the Australopithecine Predatory Habit," *American Anthropologist,* 1958, vol. 60, no. 5, pp. 923—931.

[7] See Clark, *op. cit.,* pp. 113—160.

Most striking among these latter are the small brain case with a relatively large jaw, which give it an appearance not unlike a chimpanzee or gorilla. But this has to be interpreted not as a development in a simian direction but a phase in the general direction of hominid development. The cranial capacity has been estimated to be in the neighborhood of about 600 cc, with an estimated range of 450 to 700 cc. which would exceed the largest gorilla on record who is larger in body size than *Australopithecus* and whose capacity is 685 cc. What is more important than size is the fact that endocranial casts show greater affinity with the hominidae than the pongidae in the presence of the sylvian notch between frontal and temporal lobe, and also the richness and complexity of the convolutional impressions. Also more hominid is the rounded forehead, and greater cranial height. Similarly the muscle attachment on the occiput is low as in hominid forms. In general, with the exception of the face, the skull bones are well developed in the direction of hominoid forms. Furthermore, the shape of the dentition, and the shape of the palate and even the teeth are more like those of a human than those of an ape. In regard to the limb skeleton, there is undoubted evidence that *Australopithecus* had erect posture. This is significant, for the skull seems to suggest by its retention of many simian features an uneven or asymmetrical development.[8] The most important remains that document erect posture are the pelvic bones which correspond in all important features to those of modern man, except, perhaps, that they are slightly smaller. The erect posture, so clearly represented by the pelvic bones, is further corroborated by the lower limb skeletal remains which resemble the hominoid femur, and reflect a mechanical adaptation to completely erect bipedalism.

The position of *Australopithecus* then in regard to earlier fossil remains, and to later ones to be discussed below, may be said to be on the hominid branch that eventually leads to

[8] This is very possible when functional aspects are considered, especially the possibility that Australopithecus may not yet have been in the possession of fire (cf. S. L. Washburn, "The New Physical Anthropology," *Transactions of the New York Academy of Sciences,* II : 13 : 7, pp. 298—304). Also the problem whether Australopithecus was a hunter is still being debated (cf. the exchange in *American Anthropologist,* volumes 59 (1957) and 60 (1958).

the genus *Homo*, i.e., on the branch *Hominidae*. But it appears that no certain conclusion can as yet be reached as to whether or not this fossil form represents a kind of first "man." Some, like Dart, have suggested that he was an animal-hunting, flesh eating, shell cracking and bone breaking ape. The authorities are not in agreement whether this was done by *Australopithecus*, or by some hyenas.

The problem is further complicated by the reported appearance of some cultural materials, which may and may not have been used by *Australopithecus*. In any event, the exact taxonomic position has to be determined by further study, but in the meantime authorities like Clark, who are more disinterested than its discoverers, provisionally class these fossils in the ancestral family of the hominidae from which other genera of hominidae may have been derived.[9]

The fossils to which attention must next be directed are those coming from Central Java and from China. The first find, already mentioned before was named by its discoverer, Dubois, *Pithecanthropus erectus*, because in addition to the ape-like skull cap he found a femur which suggested erect posture. Since the original finds made in 1891 still further fossils from similar strata, and older strata were recovered just prior to World War II by Von Koenigswald in the same area of Central Java. The best geologic opinion as to the dating suggests that they come from lower and middle Pleistocene times, that is they are "younger" than *Australopithecus* finds. Dating here, though more secure than in South Africa, nevertheless is based on faunal correlations. But the stratigraphic record is good and distinct. This group of fossils is well represented by at least four skull bones or parts thereof, jaw bones, many teeth, and a femur.

Although these finds were given by von Koenigswald and Weidenreich specific names, partially because of the variation in size, it seems desirable to follow Clark's classification, which asserts that on morphological grounds, all the finds belong to one species, *Pithecanthropus erectus*, though he is willing to admit that there may have been "races."[10] This group of fossils may briefly be characterized somewhat as

[9] *Op. cit.*, p. 160.
[10] *Op. cit.*, p. 87.

follows: A cranial capacity on the average of about 860 cc with a range of 775 to 1000 cc at the very most. The endocranial caste suggests resemblances to the *hylobates,* though it is much larger, and has a much more complicated sulcal pattern. But in relation to overall body size, the brain is small. The skull itself is rather flatheaded, with a receding forehead, maximum breadth of skull is much lower down on the parietal region than in modern man. There is also a median sagittal ridge, though very slight when compared to some of the apes. Further, there is a very marked postorbital construction which accentuates the very pronounced supraorbital ridges. The occipital torus is higher up on the head, suggesting powerful neck muscle attachements at the back of the head. On the other hand, the head seems to have been balanced near the fulcrum on the spinal column, a distinct hominid feature. The palate though much larger than in man has nevertheless hominid contours. The face, however, is quite prognathous. On the other hand the mandible shows hominid features in general contour although there is no chin. Teeth show a mixture of simian and hominid features, with a slight overlap of the canines. Also simian is the increase in size of teeth from front to back. On the other hand, the dental arcade is parabolic, and there are other hominid traits in the teeth, too numerous to be mentioned here. Most important is the fact that the femur is in no way different from that of *Homo sapiens.* In general, it may be said that this group of fossils shows a number of gibbonoid similarities. But it must also be remarked, that modern gibbon and *Pithecanthropus* are not coequal in time so that such comparisons serve only to show very remote relationships.

The closely related fossil from the Chou Kou Tien Cave near Pekin, China first found by Davidson Black in 1927 and named by him, *Sinanthropus Pekinensis* on the basis of a tooth alone, are now very numerous and shed considerable light on the Genus *Pithecanthropus.* This group of fossils is known from fourteen calvaria, portions of facial bones, many teeth, and a few limb bones all from middle Pleistocene times. It generally shows many similarities to Java man, just discussed, but also some differences, however, not of a generic kind. These may be listed as follows: The cranial capacity is greater

(1075 cc average, range 850 to 1300 cc), there is greater variance in size of skull which may show sex differences, palate is smaller and more hominid than in the Java fossil, but the mandible is still very robust and without a chin, while the ascending ramus is quite broad. The dentition is exceptionally well known, characterized by great variation in size, shape and robustness, but the canines do not overlap or project as in Java man. Most importantly, the femora, humeri, clavicle and carpal cannot be distinguished from Homo Sapiens. The height has been estimated at 5½ feet, that is, this fossil was shorter than Java man. In making an overall comparison it can be said that Java man generally is somewhat more "primitive." Though according to Clark, morphologically they are quite similar, differences are only to be found in specific traits. There is, however, this significant difference: associated with the Peking finds were chopping tools, hand axes, simple flake tools also animal bones, and hearths, not to mention deer bones and hackberry seeds.

All this suggests, and there is general concensus of opinion, that *Pithecanthropus* stands in an ancestral relationship to *Homo*. It is not to be interpreted that this genus is itself the ancestor of man but that the genus shared a common ancestral form with the genus *Homo*. The transition, by this hypothesis, probably occured in some other part of the world. It seems, then, that *Pithecanthropus* represents a radiation away from the Pongidae. In this view *Australopithecus* is intermediate between Pithecanthropus and the Pongidae, suggested by erect posture, while yet retaining some simian feature of the skull.

Now directing the focus of discussion on Europe, there is a long series of highly variable fossils already mentioned, the group *Homo neanderthalensis* or simply Neanderthal Man. All these fossils are said to come from the first phase of the last Glaciation (Wurm 1) and are known from nine widely separated sites over western Europe. The fossils from these sites present consistent differences from other forms so that the group may be discussed as a species of *Homo*, which will facilitate comparison with *Homo sapiens*.

The type is characterized by some striking similarities with some earlier fossils already discussed. For instance, there is

still the low dome, the absence of a forehead, the height of the occiput which suggests powerful neck muscles, the absence of a chin. But there are also significant differences: the cranial capacity is much larger ranging from 1300 to 1600 cc, which brings it well into the range of *Homo sapiens;* the massive, but uninterrupted shelf-like torus over the eyes, the slight backward position of the attachment to the spinal column on the skull which is reminiscent of a more ape-like feature. The limb skeleton too is relatively coarse, and the femur is curved more than in some fossils already discussed. When to these characters, some simian features of the cervival region of the spine are added, the emerging posture seems to be halfway between man and apes. In metrical dimensions too, Neanderthal Man is generally outside the range of those recorded for *Homo sapiens.*

There are some important considerations which are not directly related to the shape of the fossils themselves. First, they are restricted to Europe. Secondly, they seem to have been relatively short lived. This means, that climactic conditions during the first and most severe phase of the last glaciation could have contributed to this unusual development because selection would have been severe, chance for genetic drift maximized, and migration reduced. Thus, the interpretation given to Neanderthal Man is that he represents a radiation from some more ancient fossil which is ancestral both to *Homo sapiens* and to *Homo Neanderthalensis.* There is some evidence for this proposition which will be discussed next.

Mention should first be made of the fact that Neanderthal man was associated with a distinct cultural tool tradition generally referred to as the Mousterian. Since this defines a time period, it is convenient to use it also as a time marker in prehistory. Now, the evidence for a more humanlike development prior to Mousterian times comes from a long series of fossils referred to by Clark as Premousterian and early Mousterian *Homo sapiens.* This group of fossils, which comes from about eight sites in Europe including Eastern Europe and one from Mt. Carmel in Palestine, have sometimes been included with the Neanderthal group, primarily because they have a similar torus over the eyes as does the classic Neanderthaler. However, even in this feature differences

must be noted. This torus, though well developed, is discontinuous, much as in *Homo sapiens.* But there are many other features, such as a rounded occiput, well developed forehead, less massive jaws, with the upper jaw being hollowed rather than bowed out, and with limb bones resembling those of modern man, both by virtue of lighter construction and straighter shafts than those of Neanderthal man.

It is interesting to note that of all the changes that took place at the time of the divergence of *Homo sapiens* and *Homo Neanderthalensis,* the enlargement of the brain is most noteworthy. This enlargement was associated with exaggerated development of the eye ridge, jaws and palate, and retrogressive changes in the limb skeleton in Neanderthal Man, while in *Homo sapiens* it was associated with a recession of the eye ridge and the jaw, diminution of teeth, a more rounded head, with an upright forehead, and the retention of limb characters already acquired much earlier, as for instance, in Pithecanthropus.

A discussion of the Neanderthal population is not complete, however, without calling attention to two fossils, one coming from Northern Rhodesia and the other from Java. Both resemble Neanderthal man in some features. Rhodesian man has eye ridges very much like those of Neanderthal man, is also very robust, quite flat headed with receding forehead. But in some other features it is distinctly more modern, as in some metrical features on the skull, absence of a backward rotation of the occiput, and the fact that the pelvis, sacrum, and limb bones are very much like those of *Homo sapiens.* Study of the artifacts reveals an upper Pleistocene date.

The fossil from Java's Solo River is also identified with an Upper Pleistocene date. It resembles in many respects Rhodesian man, but in some others (cranial capacity and position of foramen magnum) approximates more closely that of Neanderthal man. Again, limb bones are slender and straight shafted. But no firm conclusions can be drawn at this time as to their relationship to Neanderthal man because of the paucity of other fossil finds. It is possible, in fact, to give at least three kinds of interpretations to these finds but the choice of one specific interpretation will depend on future evidence. These may be given here, because they illustrate

the difficulties of not just classifying fossil remains, but also of showing relationships, especially when there is a paucity of data. Thus, Weidenreich suggested that Solo man is derived from Pithecanthropus, giving rise perhaps to the modern mongoloid race. Another, view suggests that both Rhodesian man and Solo Man are aberrant forms of Neanderthal man, implying thereby a very wide distribution of Neanderthal man. A third interpretation is that the Neanderthaloid population provided the basis for independent evolutionary differentiation of some of the present day races. Clark[11] suggests this to be a possibility, but in terms of what is known of mammalian evolution in general, it is not very probable.

In what has been said in the foregoing paragraphs, one may propose that the development of *Homo sapiens* took place in Pre-Mousterian times, provisionally into middle pleistocene times. That is based on the fact that by this time no significant anatomical features can be found in pre-Mousterian *Homo sapiens* which distinguish him from modern man. The question might legitimately be asked, what happened to the Neanderthal man? Unfortunately no definite answer can be given to this problem. It is possible of course that the more progressive species of *Homo sapiens,* which also brought with it a new culture of more finely worked tools, displaced in the course of time the older Neanderthalers. Or else that the Neanderthalers became extinct for reasons not connected to contacts with *Homo sapiens,* but that they encountered some disaster or fell prey to disease.

In this connection some remarks must be made about fossil races. If it is difficult to distinguish middle pleistocene man from modern *Homo sapiens,* it becomes immediately clear that the origin of modern races is even more difficult to determine when one is forced to rely on fossil evidence alone. It may be said right at this point, that most anthropologists are quite certain that modern races as we know them are a new and recent phenomenon. The difficulty arises from the fact that distinctions between modern races are literally superficial, e.g., skin color, hair texture, eye shape, nose forms etc. Furthermore, no single individual fossil can be used by the taxonomist

[11] *Op. cit.,* p. 79.

to establish *racial* differences, because race is dependent always upon measurements from a large population, and of course fossil remains are never to be found in large quantities. Thus differences between individuals of fossil *Homo sapiens* may be due to individual variation rather than to racial differences. What is known of measurements and morphological characters of modern races always derives from long series of skeletal materials, not single individuals. From such series it is also known that there is considerable overlap between them making it practically impossible to assign an individual to this or that class.

Thus the paleontological record is devoid of direct evidence of the divergence of various races. In any event, race formation has been an on-going process for all species at all times. But since races are unstable, that is, isolation which produces racial differences is just as often interrupted by migrations and other changes, the question of the origin of modern races becomes rather academic. This, however, is not to be construed to mean that races are not a reality, but we may defer to a later discussion the development of races, which so closely approximates the development of species.

The question as to where the species *Homo sapiens* originated is still unanswered. Fr. de Chardin[12] has high hopes that future work will turn up fossil evidence in Africa. He suggests this from indirect evidence: All expeditions sent out to Asian marginal areas have brought forth no evidence of early man, while at the same time both in East and South Africa more recent researches have brought forth considerable materials which are ancestral to man. Thus he suggests that it would not be unreasonable to look there because of the higher probability of discovering more evidence on the development of man.

On the other hand Dobzhansky[13] feels that such a question on the origin of *Homo sapiens* is rather meaningless because new species do not arise in any single place but in large territories. A species, he points out, is a Mendelian population which lives in a more or less extensive area and which gradually alters its genetic composition. Mankind, he argues,

[12] *Op. cit.*, pp. 98—99.
[13] *Op. cit.*, pp. 333—334.

preserved its specific unity throughout its evolutionary development during Pleistocene times, although it always was and still is subdivided into races. Human evolution in his view never developed different single species, some of which might have become lost, while others survived. Thus, the whole of the old world becomes the "stage," so to speak, for the development or evolution of man.

If we substitute the words Family Hominidae for species and genera for races of Australopithecus, Pithecanthropus, and Homo, such a view may well be entertained. By this is meant only the organic development of the branch *Hominidae* in which all of the old world seemed to have participated, in the sense that all fossil populations contributed to the common gene pool of the Hominidae. The description of the fossil record above was based on this, rather than on another type of taxonomic classification. Words, of course, make not too much difference, but they stand for classes of phenomena, and it helps to keep these constant, in discussing so complex a problem. We shall see in the next section that such a view is of course supported by modern genetic developments which provide the key to the understanding of the "origin of species," a key which was unknown in Darwin's day.

Genetic Interpretation of the Fossil Record

In the previous section the fossil record was examined rather quickly and superficially. An attempt was made to show the resemblances between the various fossil forms, because, as Father Cooper[14] has pointed out long ago, "Things that resemble each other are not necessarily related genetically, but where the resemblances are so numerous, so specific, so striking, and so complex, it is very hard to avoid concluding to genetic relationship, especially as we have abundant evidence — within even the circle of the human race itself — that evolutionary changes do occur up to a certain degree."

Now these resemblances have taken on new meaning with the development of genetics, and with the recognition that

[14] John J. Cooper, "The Scientific Evidence Bearing Upon Human Evolution," *Primitive Man,* 1935, 8 : 1 and 2 : 1—56.

although certain phenotypical characteristics seem to be reproduced more or less in the offspring, the real unit of heredity is not blood, but a unit of molecular dimensions, called the gene. The genetic inheritance represents the conservative force in reproduction which assures the offspring of becoming a copy of the parent. But, of course, the copy is never perfect, and in Darwin's day, this was assumed to be the result of the mixing of two strains from unlike parents. It was not until Mendel's law of segregation and independent assortment was rediscovered at the turn of the century that an understanding of biological changes was greatly advanced. The new genetics also demonstrated that the organic forms observed represent the end products of the interaction of the genetic units with each other and with the environment. This led to the recognition that the units of heredity are rarely lost, but may reappear, depending on combinations of recessive and dominant alleles in heterozygous populations according to Mendel's laws. This is very important to an understanding of the variety of forms that we find in the fossil record, and the recurring similarities of morphological types, throughout the human fossil record. In other words, modern man has to a large extent the same genes as the fossilized ancestors did. This, however, represents an oversimplication, because there are losses, there are changes in genes themselves and there are changes in the frequency of different kinds of genes in populations, all conspiring to produce different kinds of genotypes under the influence of selection which are responsible for the variety of morphological types both in the fossil record, and in modern man.

It may be valuable, therefore, to review briefly the genetic mechanisms which seem to be responsible for changes in organic forms.[15] The knowledge at hand is mostly derived from work done on non-human organisms. This seems justified because, as Father Cooper[16] observed, man's body must obey many biological rules which seem to be essentially similar to those of non-human organisms, and if the principles apply

[15] Most of the description of genetic mechanisms is derived from William C. Boyd, *Genetics and the Races of Man,* Boston, 1955, ch. V, pp. 131—161, and Dobzhansky, *op. cit.,* chaps. 2—8, pp. 23—191.

[16] *Op. cit.,* pp. 15—16.

there, they must also apply to man. From the genetic viewpoint, evolution is essentially a change in gene frequencies. To understand this it is important to recognize that although genes do not change, and hence constitute the conservative force mentioned above, they do combine in different ways in different populations to produce different genotypes which will interact with the environment to characterize certain populations. The force for change is mutation, and this force alters the gene so that changes are possible. If the altered gene has adaptive value, it will become established in a population. The third factor in change comes about through the loss of genes. As far as is known, these processes have been responsible for changes in the past. The changes brought about by these processes may be discussed as four genetic mechanisms which are primarily responsible for the alteration of gene frequencies in a population—they are: Mixture, mutation, natural selection, and genetic or random drift.

Mixture is a very frequent phenomenon today and undoubtedly it has been important in the past. When two populations with differing gene frequencies come together and interbreed, the resulting population will be altered, according to the proportions of new genes introduced by the mixing populations. Consider a pair of hypothetical genes D and d, for shortness and tallness respectively, and assuming that tall stature is recessive to short stature, and the hetrozygote Dd produces intermediate stature, and that equal numbers of the two parent stocks were involved, then the result of the crossing of a pure short race DD with a pure tall race dd would be the production of a new race in which the population would be composed of 25% tall, 25% short, and 50% intermediate individuals. Note, however, that there are still tall and short people, and that for no one individual can it be predicted what he will be. This also illustrates, that no genes have been lost, but rather that they have been, so to speak, reshuffled in the population. The assumption here is of course that no changes have taken place in the genes themselves.

Thus the effects of mixture will depend on gene frequencies in the component populations, and the relative numbers of individuals in each population. Though this can be calculated

mathematically, unfortunately for man very few predictions can be made because we do not know the genetic composition and the numbers involved in matings.

The next mechanism to be considered is mutation. There are many kinds of mutations, involving changes in whole sets of chromosomes, in single chromosomes, in amounts of portions of chromosomes, in relations of parts of chromosomes and finally, the one definitely known to be operative in man, changes in the composition of the individual gene. (The other gene changes may eventually also be shown to play a role in human genetics).

It has been objected that mutations produce deleterious efects and hence bring forth degeneration rather than evolution. But it must be understood, that most mutations which occur are of a rather minor moment, and, as Dobzhansky[17] points out, contribute to what has become to be known as micro-evolution. That is to say, certain minor changes, which may not even be visible, may, if the environment changes, become important and help the organism in adapting to the changed environment provided that mutant has been perpetuated in the offspring. There are on record observed mutations which have had more dramatic efects, such as the shortening of legs on sheep both in New England and independently again in Norway. But generally, as will be seen presently, they are not that far-reaching.

Genes generally mutate, but do not have to, in one general direction. In fact, reversal or a return to the original structure has also been observed. What is more important is the fact that a mutation does not change the species or race. Rather, it is the summation of many mutations which bring about lasting and fundamental changes. This seems to be contradicted by the fact that mutations have been observed to be harmful or even lethal to the organism. But it is here that the idea of selection plays an important role. Those individuals which have harmful mutants tend to be eliminated, while those which do not possess these will perpetuate themselves. Furthermore, genes always act in combination, and often the deleterious effects do not become obvious. On the other hand, some mutations, which, if not too frequent in one environment,

[17] *Op. cit.*, pp. 91—108.

may be perpetuated, even though harmful and may in an altered environment be responsible for the very perpetuation of the species, though the species will now be slightly altered. This effect has been noted repeatedly as for instance in the bacterial resistance to streptomycine, the resistance of the fly to DDT, and possibly the resistance of man possessing the sickle-cell blood trait to malaria. Thus, mutations play an important role in the adaptation to the environment, even though they may appear at first as "useless" mutations. The advantage then lies in the fact that the small changes help the organisms to adapt at some critical time when the environment changes. In the long run, it may be said that mutability is a useful trait.[18] This knowledge the early evolutionists did not have. Instead they struggled with the problem in terms of inherited acquired traits.

However, it must be pointed out that in a stable environment, the rate of mutation for each gene may be so slow that it cannot be observed in any easy manner. Very little is known about the process in man. For instance Haldane (1935) estimated that the allele of the hemophylic gene mutates about once in every 50,000 individuals per generation. But this is a high rate, and since the action of selection is to eliminate this trait it would have disappeared long ago if it did not mutate again and again. Thus a kind of equilibrium has been established between the two opposing forces of harmful mutations and natural selection and the trait remains in a population at about this rate.

Selection as a mechanism was of course one of the earliest and most important mechanisms to explain evolution, and the subtitle of Darwin's *Origin of Species* makes this eminently clear. But while in Darwin's explanation natural selection meant more or less the survival of the fittest, genetics has shown that this process is rather more complicated. Selection then means "that organisms possessing certain characteristics survive in relatively large numbers, and leave relatively more offspring, than do other organisms of the same kind possessing other characteristics."[19] Selection then favors the characteristics best adapted to a certain environment, and can be inter-

[18] *Op. cit.*, p. 107.
[19] *Op. cit.*, pp. 141—142.

preted only if the environment is known. This cannot be overstressed, because as was pointed out above, it is not possible to predict the direction of future developments even if mutations are known and their rates are known unless also the environment is known. And the variables that compose an environment are so numerous, so uncontrollable that it is impossible to predict forward. But for purposes of interpreting the fossil record, knowledge of this mechanism is extremely useful in understanding evolution.

Genetic selection can be calculated mathematically, and has been verified experimentally. The most sophisticated mathematical treatment of selection is important here because it gives an idea of the number of generations it takes for changes to take place in the racial history of man. Thus a dominant gene, having a selective advantage of one per cent (relatively high) to reach a frequency of 100% in a population takes 900,230 generations. This suggests then that selection works very slowly. The slow change represented by the fossil record seems to verify this. There are changes that do occur more rapidly, but then the action of mutation (which may be advantageous or disadvantageous) must be brought into the picture. Also changes come about more rapidly by the action of mixtures of several populations, when it is possible, by the introduction of new genes to increase the selective advantage.

Although people once doubted the effectivenes of selection, today there is considerable evidence especially from lower organisms that selection is very effective, and this can explain the sweeping changes that are represented in the fossil record. To observe selection was of course denied to Darwin. A good example of selection is the increase of the incidence of dark coloring (melanism) in certain moths. Melanism has been observed to have increased in the last century, and this change has been associated with progressive industrialization of the areas where these dark colored moths are found. In some cases the entire population of moths has become melanotic. Now it is worth noting that melanism in moths is generally to be inherited as dominant. From Haldane's formula it can be calculated that selection is very rapid by increasing the frequency of the dominant gene which had an appreciable advantage in natural selection.

The outcome of selection usually is the better adaptability of the organism to the environment. Experiments and many observations have shown this to be the case. But adaptation is rarely if ever perfect. However, adaptation seems to become more perfect where the density of living forms and thus the intensity of selection is greater, that is to say where the number of individuals competing for the same ecological niche is greater. On the other hand, where this pressure for selection is low, there is then a tendency to develop more varieties. One wonders if there is not an application to this also in higher organisms when the decrease of the varieties of wild animal forms is considered which yielded to highly adaptive man.

An example of selection which is fairly well documented and which directly relates to man is the Rh positive and negative blood group gene. If Rh negative and Rh positive had equal frequencies in a population the action of selection would be zero. If the incidence of the two genes is unequal, the less frequent gene would be affected to a greater extent than the more common gene, so that in the absence of other influences, the less common gene would be eliminated. The practically complete absence of the Rh negative gene in Australian, Indonesian, Asiatic, and American Indian populations might suggest that selection already took place before these populations left Asia. A similar sort of reasoning is being applied to the problem of the distribution of the sickle cell phenomenon in Africa, which eventually may help to shed light on the mechanism of selection, especially as it pertains to modern man.[20]

Eventually, perhaps the "racial" characters of man may be better understood as to how they have been acquired by man during this process of natural selection, such as skin color or somatic type. Coon, Garn and Birdsell (1950)[21] have done some work on this, but this has been contested, because man, unlike lower animals, has a culture which permits him to

[20] Cf. James V. Neel, "The Study of Natural Selection in Primitive and Civilized Human Populations," *Natural Selection in Man* (J. N. Spuhler, ed.), Detroit, 1958, pp. 43—72.

[21] C. S. Coon, S. M. Garn, J. B. Birdsell, *Races: A Study of the Problems of Race Formation in Man,* Springfield, 1950. See also Neel, *op cit.*

constantly modify the environment to suit himself, rather than the other way around.[22] But on the level of micro-evolution, there are undoubtedly many changes in which natural selection works directly even on man.[23]

The fourth and last evolutionary mechanism to be explored is known as random genetic drift, or isolation, because it depends for its operation on the isolation of one small population from other populations with which it could interbreed. Isolation must have been a factor of great importance in the early history of man when geographic or other barriers prevented people from mixing freely, especially during glaciations in certain parts of the world. Reference to this process was made earlier in connection with the Neanderthal fossils. The basic mechanism is simple enough and may best be described in terms of an example.

Assuming a very small population of say only four men and four women was placed on an island. If they came from a normal European population, it might well happen that no individual of blood group B (which accounts for only 10 to 15% in European populations) would be represented. But even if a B individual were represented, by chance, the individual most likely would be a heterozygote, that is of the genotype BO, and any child of his has a 50-50 chance of not belonging to bloodgroup B. Even if there were a fair number of progeny the gene B might still not be represented in the new generation, and as soon as this hypothetical original group B individual passed the age of reproduction or died, the gene would be irretrievably lost to the island population unless it were re-introduced by mutation. Furthermore, the possibilities of loosing the B gene are enhanced by the individual possessing it getting killed before maturity, by sterility, or for some other reason.

Sewall Wright has shown mathematically that even in larger populations the chance fluctuation in gene frequencies with succeeding generations will often result in a gene being

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[22] Cf. Charles G. Wilber, "Physiological Regulations and the Origin of Human Types," *Human Biology,* vol. 29, no. 4, pp. 329—336.

[23] Cf. S. L. Washburn, *op cit.,* pp. 298—304; Dobzhansky, *op cit.,*; W. W. Howells, "Universality and Variation in Human Nature," *Current Anthropology* (W. L. Thomas, ed.), 1956, pp. 227—236.

lost. A subdivision of a species into isolated populations, plus time to allow a sufficient number of generations to elapse (the number of generations being a function of the population size) is all that is necessary for race formation. The isolation may be brought about by many factors, such as geography, ecological isolation, social isolation and so on.

One of the important phenomena which makes this mechanism of genetic drift very important for evolutionary theory is the factor of size of population. This has been studied experimentally for non-human organisms, but probably also operates in man. The smaller the population, the greater will be the effect of drift. Reductions of populations have often been observed through such phenomena as social fission, when small groups of people have left the native habitat to establish themselves in isolation elsewhere. Also diseases may play an important role in this reduction of a population to a point where genetic drift might become operative at a greater rate than in larger populations. Furthermore, it should be pointed out that the effective breeding population in man is generally considerably smaller than the total population. Factors of age, fertility, social taboos, etc., greatly limit an effective breeding population.

This mechanism of genetic drift has also other consequences, some of which are not necessarily beneficial. In small populations alleles favored by natural selection may actually be lost while disadvantageous alleles may become fixed. In such cases, evolutionary changes by this same process of drift may go against the direction of selection. This may perhaps explain the aberrant forms of certain populations possibly contributing to their extinction.

It is probable that the four major mechanisms for producing change rarely work singly, but in combination. The relative importance of each for the future of the population under consideration seems to depend upon size of the group or groups involved, and partly upon accident, which is another way of saying that we have as yet little knowledge of the causes of mutation though we know that radiation plays an important role, and that chemical changes do also. We can conclude however, that as populations increase, genetic drift becomes much less important, and other factors play a much

more important role. It seems well established now, that these mechanisms do in fact produce new races, and eventually also new species. No doubt other mechanisms are at work but, at present, these seem to be the most important ones for the understanding of man's development and the differentiation that has taken place and continues to operate in the formation of ever new races.

The theory of evolution as sketched here then has progressed a long way from that proposed by Darwin a hundred years ago. This is not to suggest that Darwin was wrong, but rather that the trend has been to confirm the rough outlines that he drew in his *Origin of Species*. His greatest theoretical contribution was in his recognition of the function of natural selection, though he could not know what its mechanisms actually were. The other factors which he thought operative were: Inherited effects of use and disuse, inherited direct action on the organism by external conditions, spontaneous variation. These have been proven to be not so wrong, but ill-defined in terms of what is now known about the genetic mechanisms of inheritance and the causes for variation.

The burning question, however, remains. To what extent does natural selection operate in man, when one considers the fact that man is in a position to make choices, to distinguish between good and evil, is capable of rational thought, and able to symbolize. Some over-enthusiasts have suggested that man is nothing but an ape with a special number of tricks added on. But such famous evolutionists as Huxley and Simpson[24] disclaim that man is "nothing but." Rather, Simpson states: "It is a fact that man is an animal, but it is not a fact that he is nothing but an animal." And he goes on to list what he considers the most important features: "... the interrelated factors of intelligence, flexibility, individualization, and socialization. ...in Man all four are carried to a degree incomparably greater than any other sort of animal."[25] Further he points out that man is exceptional in that he is the most adaptive organism, one of the dominant forms of life which has successfully displaced competing forms, and yet he is the

[24] George Gaylord Simpson, *The Meaning of Evolution,* New Haven, 1950, p. 283.
[25] *Op. cit.,* p. 284.

most recent addition, not independent of the environment, but capable of changing it to suit himself to a degree that no other animal is capable of, and his productive efficiency is higher than in other animals, especially through postnatal care. He points out, that a fundamental difference lies in the fact that man is not dependent for survival on inherited characteristics, but through the process of learning,[26] conceptualization, and social organization can transmit acquired traits to his offspring thereby short-circuiting the slow genetic mechanisms of lower animals through the mechanisms of adjustment provided by what anthropologists call culture.

Thus even from a naturalist's point of view the gap between the animals and man is still not bridged in spite of much work of an experimental nature that has been carried on with higher primates. Twenty-four years ago Father Cooper[27] said in his excellent paper on the evolution of man that the gap between mental development of man and that of the apes is too great to be bridged. Though he did not rule out the possibility of mental evolution, the evidence seemed too negative at that time to warrant such considerations. Eisely[28] reviewed the literature on just this problem twenty-three years later and notes that "The gap between man and ape is not as the early Darwinians saw it — a slight step between a gorilla and a Papuan, or a chimpanzee and a gibbering Hottentot. Instead, it stretches broad and deep as time itself." He also points out that in spite of much work in which he collaborated, the interpretation of psychological evolution is highly speculative, because the critical moment when primates came out of the trees is perhaps least understood in regard to the forces that produced this change. Even for the *Australopithecus* it has not yet been established whether they were hunters or the hunted. One thing seems to emerge, however, that with the displacement of dependence on inherited adaptive mechanisms by the culture-building brain a tremendous change took place. How this came about, anthropology cannot answer

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[26] Cf. Simpson, *op. cit.*, pp. 284—287.

[27] *Op. cit.*

[28] Loren C. Eiseley, "Fossil Man and Evolution," *Current Anthropology* (W. L. Thomas, Jr., ed.), 1956, pp. 61—78.

any more than it can answer the fundamental question of first causes in life itself.

The foregoing has primarily been an attempt at looking at the material causes for evolution, and the theory that was here presented is the work not of Darwin alone, although built upon his first insights, but is synthetic, the work of many men, and many ideas which have been brought together into a more or less coherent whole which can answer some of the questions that could not be answered in Darwin's day. Like all theories, however, it does not explain everything, and is not supposed to. But rather, the function of theory is not only to explain, but also to guide our search for more data and raise further questions and through this process increase our understanding of natural phenomena.

Some Implications

It would seem that modern evolutionary theory (and one might add that there is remarkable convergence in theorizing among those authorities who concern themselves with the problem of evolution) does explain both the continuity of the species as well as the variety and similarities that occur between forms that existed in the fossil record as well as those to be found today. Although it is a consistent theory, that is, it explains much that was once contradictory and does it well, does this mean that the theory is good? No alternative theories so far have come forth which equally well explain phenomena of change both past and present. There is also another consideration which must not be overlooked. A good theory, it is often maintained in empirical sciences, must be able to predict. It may be said that evolutionary theory cannot predict forward; but to the paleontologist it has been very helpful in "predicting backwards." That is to say, it has served as a guide line for looking in certain places and in certain strata in the crust of the earth to locate new materials which gradually fill out the fossil record, and which may be expected to do so at an ever increasing rate in the future. It has also aided materially in discovering the now famous Piltdown hoax. Theory demanded some other morphological form than that of Piltdown man. But in the absence of any reliable way of testing for its antiquity, the Piltdown skull

was provisionally grouped with early man. Yet fifteen years ago, my Professor of Physical Anthropology, Krogman, who had seen the skull, felt very uncomfortable, and always placed it outside any phylogenetic classification. He was not alone in this, and its was with the discovery of certain chemical techniques that the hoax could be established.[29]

Aside from these considerations, other criteria by which a theory may be judged can be advanced. A recent article suggests that simplicity and elegance are the fundamental principles that circumscribe the qualities of theory.[30] Though this article refers to theoretical physics the problem has also been discussed elsewhere. In this essay, simplicity is defined as "the principle that postulates the resolution of a physical problem to the fewest possible mutually independent elements in terms of which the problem is quantitatively represented into simple mathematical formulae." It would seem that if we substituted the word biological for physical, one could have here a criterion which might be applicable to the theory of evolution. The mutually independent elements that have been isolated so far are certainly the genes, and the factors which change in gene frequencies. These, as was pointed out several times, can be represented in relatively simple mathematical formulae. However, as was indicated above, there is reason to believe that the biological sciences are still a long way from identifying all the "mutually independent elements," the search for which is greatly complicated by the fact that in living matter all parts are interconnected and work on each other. Even the phenomenon of change in the gene itself is as yet little understood.

The second criterion of elegance is defined as "the principle that postulates the adequate representation of a physical problem in mathematical formulae which bestow unity, symmetry, and harmony among the elements of the problem." Again with the appropriate substitution we may examine the evolutionary theory. As already pointed out, mathematical formulations are the order of the day in modern genetics. But

[29] Cf. Kenneth P. Oakley and J. S. Wiener, "Piltdown Man," *American Scientist,* 1955, vol. 43, no. 4, pp. 573—583.

[30] Cf. John D. Tsilikis, "Simplicity and Elegance in Theoretical Physics," *American Scientist,* 1959, vol. 47, no. 1, pp. 87—96.

the very fact that we had to list four separate forces which produce frequency changes in the evolutionary process suggests that an understanding of their interrelations though appreciated is not well integrated. But integration has begun, as for instance in the calculations of gene equilibrium in small populations, which takes into account both rates of selection and mutation, and size of population. No general integration has been accomplished, and there are also problems not only with the mathematics of the problem, but also with experimental data. Nevertheless, progress is being made in the direction of bestowing unity on the theory of evolution, as was pointed out earlier. This much seems certain, the various explanations given above seem to harmonize with one another and are not contradictory, though lacking in a total comprehension.

Simplicity of a theory means that theoretically certain phenomena can be expected to happen, or that such and such was a likely way in which it may have happened. Evolutionary theory seems to do just that, and in so doing undoubtedly oversimplifies natural processes. But it provides an approximation which greatly facilitates not only discussion of the problems involved, but also understanding of the problem. It does not mean that the explanation has to stay at this level. Rather as knowledge deepens, there is a good chance that the theory becomes more complex, as in fact the history of evolutionary theory already demonstrates. At the same time, the theory has becomes more sophisticated, and in terms of the criterion above, more elegant, even without all-encompassing mathematical formulae.

Is then evolution fact or fancy? From what has been said, the question seems to be a spurious one. There are the facts of change, the facts of variability of organic forms, and there is the undeniable fact of the great antiquity of some simple forms. Unless one wants to go back to the days of the "special creationists" these facts must be interpreted in some such fashion as was indicated above. But it must be kept in mind that this is *an* explanation. There may be others forthcoming. But the weight of evidence at this time seems to favor such an explanation. It was impossible to list here all the evidence, such as the embryological, or much of the work now done in

comparative anatomy and physiology which is becoming rapidly more important to anthropology. Also it would be foolhardy to conclude that everything has been explained by evolution. It may be recalled that the problems of how the ancestors of man have become men are as far from solved as they were one hundred years ago. It may also be recalled, that any empirical scientific theory can only consider immediate causes, not ultimate ones. Nevertheless, it would seem that closer collaboration with philosophers and theologians is long overdue. It is not sufficient for each to criticize the other, which has led in the past to so many blind alleys and produced much emotionalism. What is needed is active collaboration! The recent *New York Times* news release from Rome (February 28, 1959) of a human paleontologist's visit to the Vatican, having an audience with the Pope, and the attendance at his lecture by Eugene Cardinal Tisserant, may signal a propitious moment for a new era of cooperation rather than competition. Science in the pursuit of truth never challenges dogma, but error does, and error can only be eliminated through greater efforts on the part of those dedicated to the pursuit of truth!

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PHILOSOPHICAL ASPECTS OF EVOLUTION

by

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PHILOSOPHICAL ASPECTS OF EVOLUTION

1. Introduction

The doctrine of evolution belongs to those scientific theories which have had repercussions far outside the field of science proper. The fact that scientific theories have these repercussions should not amaze us. Specialization may be a necessity in science, due to the abstract character of human knowledge, but behind the overwhelming variety of scientific methods and disciplines attuned to special problems, stands the unity of the human mind. The hidden motive of all human quest of knowledge about nature, about the material world, is the desire of man to know more about himself. Man wants to know his own origin, his nature, his destination, in short the meaning of his existence. For that very reason, even physics and chemistry, which at first sight seem to be sciences interested only in the structure of the material world around man, continually have given rise to discussions of a more general nature. In the past and present, physicists and chemists have claimed that their discoveries were of the greatest importance for theology, philosophy, psychology, sociology, etc. It is true, of course, that many times these claims have been proven false and that the scientists in question did not respect the limits of competency characteristic of their science. This, however, is not the issue at the moment. Important as it is to respect the proper boundaries between the different sciences, between science, philosophy, and theology, we should never forget that the different disciplines are not separated from one another by watertight compartments. The continual repercussions which scientific theories, rightly or wrongly, have had outside their own field clearly show that man in trying to understand nature first of all tried to understand himself, and justly so. For man knows that he, too, belongs to nature: nature is in him as it is around him.

What is true with respect to physics and chemistry, is still more true with respect to biology. In studying living nature, biology also studies man. Therefore, it is only natural that the theory of evolution, a biological doctrine, from the beginning has been tied up with philosophical and theological controversies about the position of man in the midst of nature. But apart from the general reason why any biological discipline has a close relationship with our quest of self-knowl-

edge, there is a special reason why evolution has been so highly controversial. The theory of evolution may be a biological theory, but it is one of a peculiar type. It has a far-reaching aim — namely, nothing less than to explain the origin of life and man. It pretends to say something about this origin in a scientific way, and seems therefore an intrusion into the territory of philosophy and theology. Or should we say that, thanks to the doctrine of evolution, questions about the origin of life and of man ceased to be fruitless speculation and became open to scientific research and explanation? It is not very easy to decide which point of view is right, especially not because the theory of evolution could not immediately show its true nature. For, even considered merely as a scientific theory, apart from its possible philosophical implications, the theory of evolution has something of an ambivalent character.

As a rule, scientific theories are based upon experimental data, which all have in common that they can be repeated at will. Strictly speaking of course, no phenomenon taken as a whole can be repeated. This being so, experimental science must begin with analyzing the complicated concrete phenomenon in many aspects, each of which can be repeated. If I drop my pencil, for example, at this moment, then this fall is something unique for, as such, it can never be repeated. At least some of the circumstances will be different (e.g., the time-point). Yet, the pencil can be dropped again in slightly different circumstances, some of which will be important, while others are not. Instead of this pencil I can drop other objects of the same weight, of the same size, of the same or of different material and thus arrive at the general physical laws of gravitation. These laws, therefore, do not speak about my pencil as such, they speak only about objects with a certain mass, at a certain distance, and so on. Consequently, with respect to science, my pencil does not exist as a concrete object, but in a scientific context its concreteness recedes; as far as science is concerned, my pencil exists only as an instance of a certain mass, shape, color, chemical composition, etc.

With this general attitude of science in mind we easily see the special position of the theory of evolution. For evolution speaks about the origin of life as a unique event which took

place in the past. In the same way it speaks about the origin of the various forms in which life presents itself. It contends that millions of years ago life originated from non-living matter (abiogenesis) and that by a process of gradual evolution the different forms of vegetative and animal life came into existence (macro-evolution). The other branches of biology, however, take it for granted that in the normal course of events life not only always originates from life, but also that the different generations always belong to the same type of being: horses procreate horses, cows cows, flies flies, and daisies daisies. There are undoubtedly slight differences between parents and their offspring, but these differences remain within the scope of a certain species (micro-evolution). For this reason micro-evolution can be studied by the biologist with experimental means, but not macro-evolution. We can sum up the special position of the theory of evolution by saying that abiogenesis and macro-evolution are not merely scientific, but also "historical" hypotheses. They have perhaps taken place, but biology is not able to verify them in an experimental way. We may add: it is not impossible that one day the scientist will succeed in showing us abiogenesis in his laboratory. But even then he would only have confirmed the possibility of a natural abiogenesis in the past, his experiment will never confirm it as an historical fact. For science can never verify historical, i.e., unique phenomena, it can only verify repeatable events, i.e., it can verify the concrete only in an abstract way. History, however, is never interested in the abstract, but always in the concrete.

The above is not meant as a depreciation of the theory of evolution. On the contrary, it can be said that the historical character of the theory of evolution proves its importance, because the human mind is never satisfied with merely general and abstract laws about living nature, but also wants to know the origin of life in a concrete way. (In the same way scientists are not satisfied with studying the earth only as an abstract object, they try also to discover its cosmic origin.) Nevertheless, it remains true that the historical character of the theory of evolution is one of the main reasons for its peculiar status in biology. It makes it fall outside the scope of the normal experimental means of biology. From this it does

not follow, of course, that the theory of evolution does not have any means at all at its disposal. What are these means and what are the reasons why biologists began to think in terms of evolution?

First of all there is more or less stringent geological evidence that hundred of millions years ago no life at all was possible on earth. For life can only exist within very limited physical conditions. Secondly, paleontological findings suggest that in periods when life was possible on earth, some forms of life which exist now did not exist. Thirdly, the different forms of life known to us can be classified in such a way that certain lines of development reveal themselves. Comparative anatomy, embryology, and physiology show that the same kind of structure underlies forms which at first sight seem entirely different. Therefore hypotheses can be proposed concerning the descent of one form from the other. Sometimes it can be concluded that formerly animals must have existed which are linked up with animal forms living nowadays.

Paleontological findings many times verified such theoretical conclusions. These facts show that the theory of evolution is not just speculation. Within certain limits, it can be verified by "historical" documents. Both the general grounds and the means of verifying the theory show, therefore, a more or less historical character, they confirm why biology can rightly be described as "natural history." To be natural history, however, is only one side of biology. It also wants to be a natural science. That is to say that biology wants to know the general causes of evolution. Why and in what circumstances did a new species develop?

It is mainly this problem which has given rise to many fervent discussions. Partly these discussions belong to the realm of science. As already stated, science can directly study only micro-evolution, that is to say, those differences which remain within the limits of one and the same species. Whatever mutations may have been discovered with the famous Drosophila, the pet-animal of geneticists, these mutations do not change a Drosophila into another type of animal. Consequently, the thesis that macro-evolution is caused by the same factors as micro-evolution — namely, random-mutation, selection, and isolation, is for the time being an extrapolation

far beyond the realm of experimentally established facts. It depends, therefore, more or less on his belief in the reliability of this extrapolation whether a biologist thinks that macro-evolution is scientifically explained or not.

The discussions about the causes of evolution, however, are not wholly of a scientific nature, but partly also inspired by different philosophical positions. Especially in the nineteenth century it seemed as if a scientist who did not believe in creation was forced to believe in evolution. On the rebound, Christian philosophers thought that rejection of evolution was imposed by Christian dogma. This is the more amazing because till modern times Christian tradition had always believed in spontaneous generation, i.e., some kinds of animals were thought to be generated immediately from inanimate matter. Neither St. Augustine, nor St. Thomas, to mention only these two great founders of Christian thought, had seen any contradiction between the existence of spontaneous generation and the creation of nature by God. It is really one of the greatest mysteries of the history of thought that when in the nineteenth century the idea of evolution became generally accepted in the scientific world, many Christian thinkers thought that in the name of sound philosophy this idea had to be rejected. They even used the scientific arguments against spontaneous generation as evidence for their belief in creation! And apparently they had a strong case. After a long battle lasting several centuries, it became evident in the same nineteenth century which accepted evolution that spontaneous generation had to be rejected on scientific grounds. Thus we are confronted with the peculiar situation that it looked as if the advocates of evolution postulated abiogenesis on no other ground than that they wanted to avoid the idea of creation. Whereas there was some evidence for evolution within the realm of living nature, there was no evidence at all for abiogenesis. All the available evidence pointed in another direction. However, without abiogenesis there seemed no way out; the explanation of the first appearance of life demanded either creation or abiogenesis.

It would be wrong, however, to think only of a materialistic credo as the source of the idea of abiogenesis. For many thinkers this credo did play a rôle, but it is not the only reason

and certainly not the main one why scientists advocated abiogenesis. They had a very sound philosophical reason which in itself had nothing to do with materialism, except that in the past so-called materialists did understand this reason better than other philosophers.

In order to see this reason, we have to dwell a moment upon a problem that dominates the history of biology and that is known as the antithesis between mechanicism (or materialism) and vitalism. A short analysis of this antithesis will teach us some important things about the nature of science and about the distinction between science and philosophy. It will also clarify much of the background of the dispute around evolution.

2. Mechanicism and Vitalism

The main point of the conflict between mechanicism and vitalism can be formulated in the question whether or not all phenomena of life can be explained by purely physical and chemical factors. Mechanicists answer the question in the affirmative, vitalists in the negative. The latter think it necessary to assume that in any living being there is present a special factor, a *vital force* or *entelechy*. The still current term *organic chemistry* originated from that opinion. Organic compounds were believed to be formed exclusively in living bodies under the influence of the *vital force*. It would, therefore, be impossible to synthesize them in a test tube. Scientists, however, do not like the word *impossible*, especially when it is only the reflection of the empirical *status quo*. They always try to do the impossible.

In 1828 Wöhler succeeded in synthesizing urea, and from that time on so many organic compounds were produced, that there was no longer any doubt concerning the possibility of synthesizing all organic compounds in the test tube.

However, that did not discourage vitalism. It could point at enough other aspects of living organisms to endorse its fundamental thesis that not all phenomena of life could be explained by chemistry. Famous are, for example, the startling phenomena of regulation and regeneration, studied by Hans Driesch. After a great number of skillful experiments, he pointed out that the development of a young embryo did not

follow a deterministic course, but showed an adaptability to its situation which in his opinion could only be explained by the activity of a special non-material factor, the entelechy. It seemed as if an intelligent being directed the course of events in such a way that even under extremely infavorable circumstances the embryo realised its purpose—namely, a harmonious adult animal. In emergency cases certain cells did not follow their normal development, but took an entirely different course in order to take over the tasks of damaged or lost parts. There could hardly be any doubt that the entelechy did exist.

Later experiments proved, however, that the intelligence of experimental biologists was much greater than that of the entelechy; it became evident that even the startling phenomena of regulation and regeneration could be explained by chemical and physical factors working in a purely deterministic way.

These two examples, taken from the history of biology, may suffice to make us understand the statement of von Bertalanffy; that the history of biology constitutes the refutation of vitalism.[1] And he is right, in so far as no biologist believes any longer that the phenomena of life cannot, in principle, be explained by physics and chemistry.

Does this mean, however, that the mechanistic point of view had won victory on all fronts? To answer that question, it should, first of all, be borne in mind that the general agreement among modern biologists with respect to the possibilities of physico-chemical explanations of life leaves one problem undecided. It is exactly the problem we are interested in—namely, the origin of life. All biologists do agree on the question that once the order of a living organism is given, the phenomena of life can be explained by the co-operation of the material forces, coordinated in that organism. They do not agree, however, on the question regarding the origin of that order. Some consider that order as the unexplainable mystery of life, while others view it as the natural result of the material forces themselves.

Thus, the antithesis between vitalism and mechanicism is still alive. Both parties seem to have a strong case. The mechanicists claim that the history of biology will decide in

[1] L. von Bertalanffy, *Das Biologische Weltbild,* Bern, 1949, vol. I, p. 21.

their favor as it has done in the past, because they are convinced that the position they defend is fundamentally the same as the one they defended before. The vitalists point out that all actual biological explanations start and have to start with the given order of life. According to their point of view, physico-chemical explanation in biology can, to a certain extent, be compared with the way the working of a technical product can be explained. A technical product, e.g., an engine, works entirely in agreement with physical laws; given the construction of the engine, the engine must work as it does. That does not mean, however, that material forces explain also the origin of an engine — it owes its origin to the creative power of man. In the same way, the biological order could be based entirely upon material forces, without the latter being responsible for the origin of the biological order itself.

It sounds convincing and yet we should not be convinced too soon. For serious objections can still be raised against the modern vitalistic position. First of all, it should be pointed out that there is a great difference between a living organism and a technical product. The latter is the result of an artificial arrangement of material components. The parts of an engine are given a form which is not natural to them, the form is imposed upon them by an outside force. A living organism, however, for all we know, is built up with the aid of entirely natural macro-molecular structures, its form is not imposed from outside, but is the natural result of the structure of matter. This being so, it stands to reason that biochemists are interested in a new field of research, properly called chemical evolution. They try to understand how under natural conditions macro-molecular structures could be formed on earth and they have already found many interesting facts, as, for example, the entirely natural formation of amino-acids, which are important constituents of proteins. Although still much remains to be done in this field, the first results are hopeful for the mechanistic position. It seems likely that also the last fortress of vitalism is doomed to be surrendered. In that case the victory of mechanicism seems complete. But will it really be a complete victory?

With this question we have arrived at a point in our discussion which is of the highest philosophical importance—

namely, precisely what conclusions should be drawn from the history of biology, as sketched above, which shows such a great victory for the mechanistic point of view? Should one of the conclusions be that we do not need the idea of creation any more, and another that there is no essential distinction between animate and inanimate matter?

As regards the first problem, it is not too difficult to see that the dispute concerning abiogenesis or biogenesis is of no relevance with respect to the problem of creation. For the question whether life is the natural result of complicated but normal material structures, a very special order of matter, or endowed with an entelechy in the neo-vitalistic sense, is entirely different from the question about the existence of the material universe as such. Even if all phenomena of life can be reduced to the original forces of inanimate matter, still no answer at all is given to the problem of the origin of matter itself. The latter is an entirely different problem. Therefore, G. G. Simpson is quite right in his book *"The Meaning of Evolution"*—which strongly defends the mechanistic point of view (he even calls it the materialistic view)—when he writes: "Yet the origin of that cosmos and the causal principles of its history remain unexplained and inaccessible to science. Here is hidden the first cause sought by theology and philosophy."[2]

From these considerations it should be clear that the antithesis between mechanicism (materialism) and vitalism has several aspects, and that more than one problem is involved. First of all, the scientific problem whether or not the phenomena of life can be explained by physical and chemical methods; secondly, the philosophical issue known as the problem of creation and, thirdly, the problem of the distinction between inanimate and animate matter.

We will turn now our attention to that third problem.

3. *The Abstract Character of Science*

At first sight, it may seem as if there is no third problem at all. For once the first problem, the scientific one, is solved, what room can there be left for an essential distinction between

[2] G. G. Simpson, *The Meaning of Evolution,* New York 1951, p. 135.

inanimate and animate matter? To say that the phenomena of life can be explained by physics and chemistry seems tantamount to denying such a distinction. Yet, a more thorough analysis will show us that there is a great distinction between the two problems and it will also throw a new light on the dispute between mechanicism and vitalism.

Any dispute needs a common ground, a common assumption, a common frame of reference without which the dispute would lose its sense. Mechanicism and vitalism had in common the assumption that, in principle, physics and chemistry are capable of giving a complete understanding of the inanimate material world. They argued about the question whether or not these sciences could fully explain also the animate world. Mechanicism was convinced that they could, and vitalism that they could not. According to the latter, there was a mystery of life, unattainable by science. Both mechanicism and vitalism agreed, therefore ,that if the phenomena of life could be explained by chemistry and physics, the whole mystery of life would be solved, for life would be reduced to purely material principles without any mystery.

The mistake in this line of thought lies in the starting-point —namely, the assumption that physics and chemistry adequately explain inanimate nature (for this very reason the inanimate world is often called the physico-chemical world). The assumption, however, is wrong in two ways. For the object of physics and chemistry is, on the one hand, broader than the inanimate world and, on the other, more limited. Physics and chemistry are abstract sciences, which means that their object is not the material world in its full concreteness, but only certain aspects of that world. On the one hand, their object is therefore not limited to inanimate nature, but animate nature belongs to it also regardless of the problem whether or not there is an essential distinction between them. On the other hand, even the inanimate world can never be fully explained by physics and chemistry. The correct evaluation of the status of physics and chemistry as abstract sciences is, therefore, of the greatest importance for the understanding of the dispute between mechanicism and vitalism.

Vitalism was not mistaken when it asserted that there is a mystery of life, but it was wrong in the assumption it had in

common with mechanicism that there is no mystery involved in inanimate matter.

Mechanicism was not wrong in so far as it claimed that the phenomena of life could be studied and explained by the same methods as the phenomena of inanimate matter, but it was wrong only in so far as it thought that, consequently, no mystery was involved in animate matter.

To put it another way, if mechanicism will be proved right in assuming that abiogenesis is possible, then this does not mean that vitalistic biologists are wrong in speaking about the mystery of organic life, but will show only how great the mystery of the material world is. A better understanding of this fundamental truth, which is a consequence of the fact that physics and chemistry are abstract sciences, would contribute much to the clarification of many philosophical disputes concerning abiogenesis and evolution, and especially that of the descent of man from lower forms of life. In the following we will, therefore, focus our attention on the problems of the distinction between inanimate and animate matter. It will give us the opportunity to discuss at the same time the distinction between man and animal. For it is clear that, philosophically speaking, the real problems of evolution concern not so much the transition of one form of animal-life or plant-life to another as the transition from inanimate matter to animate and from animal to man.

4. The Distinction Between Inanimate Nature, Animate Nature, and Man

In our natural attitude with respect to the great realms of nature—inanimate matter, vegetative and animal life, and finally man — we usually think of an hierarchic order in which the higher rank possesses everything pertaining to the lower plus something specific proper to the higher rank. This way of thinking is reflected in our manner of speaking. We say, for example, that the inanimate material world does not *live*, and that it does not have any sense or intellectual knowledge, but merely *exists* with its material properties. As a consequence, when we speak about the level of plant-life, *life* is added as something special to mere material being, a plant has something, *life*, which a material thing does not have. By the

same token an animal has something not found in a plant — namely, sense-knowledge, and a human being has superadded to all this his intellectual knowledge. Intellectual knowledge and life are thus considered extras, special features added to material structures, which in themselves already existed as complete entities.

As a result of this way of thinking, we make a clear-cut distinction between a non-living object and a living being. Non-living and living are contradictory terms. Something is living or it is non-living; it is living when it is in possession of that extra which we call life, otherwise it is non-living. There is no third possibility. The extra feature, life is present or not.

The same kind of clear-cut distinction is made between man and animal. Man is an animal which is in possession of something very special—reason, a spiritual faculty. This spiritual faculty is considered as totally different from anything else found in matter. When asked what we mean by spiritual, we are inclined to answer that spiritual means non-material, whereas material means non-spiritual. Material and spiritual are, therefore, considered contradictory terms in the same manner as living and non-living.

I would not go so far as to say that this way of logically handling such terms as living and non-living, material and spiritual, is entirely wrong. On the contrary, there are too many sound reasons for it, but this does not mean that there is nothing wrong with it.

Let us begin with the distinction between material and spiritual. First of all, it may be remarked that there is a peculiar inconsistency between the way we experience the presence of the spiritual and the way we evaluate that experience in the logical order. We experience the spiritual exclusively in man, that is to say in a material structure and not in any dualistic way. The spiritual faculties of man are strongly interwoven with his material structure.

Whatever reasons we may have for opposing matter and spirit, they should never seduce us to oppose them in such a way that their actual unity in man becomes impossible. There is some truth in the saying that if man had not existed, philosophers would have declared his existence impossible. It shows the danger of reflection going wrong. There are, of

course, very good reasons for opposing matter and spirit. Plato and Descartes were no fools. In reflecting upon his intellectual knowledge, man experiences the spiritual character of this knowledge. His concepts are abstract and universal and as such beyond the limitations of time and space that are typical of matter. Even concepts of material things, for example, the concepts of colors, which lose their content when there is no actual connection with the material sense-representation, are nevertheless not tied to just one particular instance. Even they are universal.

Much more important, however, for the spiritual character of his intellectual knowledge is that man is conscious of the abstractness of his concepts and is aware also of the limitations of his knowledge. Reflecting upon his intellectual knowledge, he discovers its typical limitation. In realizing his limitations man is, in principle, beyond any limitation. Because he is capable of evaluating his situation as limited, as bound to matter, he is at the same time above his situation, and that is exactly what we call spiritual. We try to express by this term the "openness," "freedom," and "self-presence" of the spirit, as contrasted with the closedness and lack of freedom of matter. Thus spiritual seems the exact opposite of material. The logical consequence of this line of thought seems to be a dualistic conception of man. Yet, if we study man as we experience him, we don't find this consequence of our reflection to be true, for man is a unity, a unity of matter and spirit. If this unity seems impossible, then something must be wrong with our concepts. In one way or another, any anthropology will have to acknowledge the basic fact of man's unity.

Of course, that unity is not a monistic unity. Monism, be it materialistic or spiritualistic, does not help us any further. Matter is not spirit, and spirit is not matter, yet both are present in man in such a way that they are united in a real unity. St. Thomas has given a sharp formulation of the problem when he stated that the *anima,* the human soul, was both *form of the body* and a *subsistent* spiritual being. It is a formulation which balances on the edge of contradiction. Yet I think it is the best formulation ever given. It would be a flagrant contradiction if matter and spirit were the contra-

dictory entities, which our way of using the terms matter and spirit suggests.

The fact of man's unity, however, shows beyond any doubt that this suggestion is wrong. The relation between matter and spirit can never be one of mutual exclusion. What then is that relation?

Above we have seen that neither biological life nor intellectual life should be conceived as external additions to material being, but as an internal unfolding or explicitation of material being. To live is the mode of *being* of an animal, as intellectual life is the mode of being of man. We can put it in another way: Matter, as such, is a reduced mode of being because it is devoid of intellectual knowledge and of organic life. There is, so to speak, a proportion between the degree of knowledge a being possesses and its degree of being. It exists only in so far as it is capable of knowing. That is the consequence of what we have said—namely, that the cognitive faculty is not an addition to matter, but an internal unfolding of its very essence. But is that consequence not absurd? Does it not inevitably lead to the conclusion either that matter does not exist at all or that all matter is endowed with cognitive faculties? The dilemma does not seem very pleasant, for both conclusions seem contrary to reality. Matter does exist and it does not even show the faintest trace of knowledge. Knowledge in its lowest form is sense-knowledge and this knowledge is a property of the higher forms of life, perhaps even of all life, but certainly not of matter as such. It is interesting to note that biologists don't agree on what level of animate nature sense-knowledge is to be assumed. The first traces of it can probably be found with plant-life, but they are not certain. In animate nature sense-knowledge appears as a faculty which gradually takes form and unfolds. This fact confirms to a certain extent the general line of thought we are following. Yet, we need more confirmation than is given by mere speculative extrapolation beyond the realm of life; we need in material activity itself something that although it certainly is not knowledge, can properly be brought in connection with it. Let us try to find this connection. It is not too difficult.

First of all, it should be remarked that matter is knowable. By being knowable, matter, therefore, is not foreign to knowl-

edge. Of course, being knowable is something passive and, therefore, quite different from having an active cognitive faculty. And it is precisely by his active faculty of intellectual knowledge, of self-presence, that man distinguishes himself essentially from a material being. Yet—and this is the point at issue—the distinctive moment is not something that is utterly foreign to matter. For in the cognitive act the knowing subject and the known object are one. Both contribute to that unity. It would be a mistake to evaluate the contribution of the known object merely as a passive potency, for matter *makes* itself known by its material activities. These activities are a kind of self-expression of matter. It is by that self-expression that matter answers the questions which the scientist asks in his experiment. Of course, this answering, this self-expression is more passive than active, because it is wholly determined by nature; matter undergoes its own activity more than it exercises it, yet there is something active too. Not for nothing do we speak of material *activity*. In its activity a material thing "knows" how to act, how to react, because it is inscribed in its nature, and by that very activity it makes itself known to man. Perhaps the best way to state the relationship between material activity as self-expression of material being and the intellectual knowledge of man would be as follows. Although there is no cognitive faculty in matter, yet the passive role matter has in the process of knowing is not entirely passive, there is something active involved too. On the level of material being something can be found that corresponds to the cognitive faculty of man. It is more passive than active, but exactly the same applies to the level of *being* of matter, for material being in a sense is also both active and passive.

We are, therefore, entitled to the conclusion that there is a proportion between the degree of knowledge a being possesses and its degree of being. We may even go so far as to say that a being exists only in so far as it is capable of knowing, on condition that we are aware of the analogous way the term *knowing* has to be understood. Or to put it another way, the higher forms of existence in nature (plants, animals, and man) are not higher forms because of the addition to matter of entirely new principles or factors, they are higher forms

because of the unfolding of something already present in matter.[3] Does this mean that the distinctions between inanimate nature, animate nature, and man are only gradual and not essential? Are we not forced to a monistic conception of man? No, we are not, for to state an analogy does not mean to state a similarity. Let us elucidate this point.

To begin with, it should be recalled that the main philosophical problems connected with the dispute around vitalism, evolution, and the unity of man find their origin in the way we define such pair of terms as non-living and living, matter and spirit. The tendency exists to define them in a mutually exclusive way. Consequently, spiritual means non-material, material means non-spiritual; they are contradictory terms like non-living and living. This way of defining is the result of our schematizing way of thinking. We have to correct this way as we have done above, but human knowledge being what it is, we are never able to correct our schematizing way of thinking in such a manner that we are beyond any schematization. The only manner of correction open to us is to counterbalance one way of schematizing by another.

Consequently, when we speak of a gradual unfolding of material being to characterize the status of animate nature and of man, we should not forget that this way of speaking is schematic too. In order to understand nature we must use both ways of schematizing, the one that speaks of gradual unfolding and the other that speaks of the addition of entirely new factors. For nature itself shows us both aspects. On the one hand, it shows graduations and never sharp distinctions. The biologist hesitates whether a virus should be considered as living or as non-living, and he can find no clear-cut distinction between vegetative and sensitive life. By the same token human babies do not show much of intellectual life, they are just young animals. On the other hand, the fact that abiogenesis and macro-evolution, if possible at all, do not belong to the normal course of events in nature clearly indicates what important and essential thresholds must be crossed by the transition from non-living to living matter and by the

[3] The difficulties to define life confirm this thesis. Whatever definition we choose, non-living structures can always be found which more or less answer the definition.

development of one form of life into another. The same applies to the gradual unfolding of the cognitive faculty. With man this faculty has a status which is essentially different from what we have called the degree of knowledge proper to matter. Yet, there is an analogy. The cognitive faculty is not an entirely new factor.

5. Evolution and Finality

It is a matter not devoid of interest to note that so far our reflections on the different status of being, proper to inanimate and animate nature and to man, did not say anything specific about evolution. Their only purpose was to point out how intimate the relations are between the different levels in nature, and how we have to consider these relations as a gradual unfolding of being. But this point of view neither proves nor disproves evolution. Needless to say, however, that this does not mean that our philosophical reflections were superfluous or irrelevant. For, although it is not the task of philosophy to prove or disprove evolution, philosophical arguments are as a matter of fact used in the discussions of evolution, and for this reason they have to be examined in order to know in what way they affect the theory of evolution.

This theory takes the line that all forms of life not only are related to one another, but that they descend from an original primitive form of life which itself has developed from non-living matter. In one word, the theory of evolution considers the general relationship between the different forms of life as *kinship*. Whether or not this is true, only biology and biochemistry can decide, and not philosophy. We have seen, however, that the problem involved is not easy to decide on account of the peculiar nature of the problem which has not only a scientific, but also an "historical" aspect. The historical data are by their very nature scarce, there is not enough to go on, and much has to be extrapolated. In such a situation proponents of the various possible viewpoints look for all kinds of arguments to bolster their respective opinions. So it was quite natural that some adherents of evolution who did not believe in creation, found in this dislike the strongest support to their doctrine — it seemed the only way out. It was quite natural too that on the rebound, some who did believe

in creation, did not believe in evolution. In their opinion the data were too scarce to go on and they searched for philosophical arguments to oppose the idea of evolution. For this reason the nineteenth century controversy about evolution gives the impression that the main dispute was philosophical. The scientific data seemed to be relevant only in so far as they endorsed or weakened the philosophical positions. Yet Lamarck and Darwin had formulated an interesting biological problem, and although in their time that problem could not be solved, the problem did stir the minds of the biologists, and they started to work on it and gradually they found more and more evidence for certain solutions or possible solutions of the problem on purely scientific grounds.

As a result there has been an evolution of the theory of evolution, that is to say there has been an historical development of the problem of evolution. Formerly the problem was tied up with all kind of philosophical considerations, now it is a problem in its own right.

Such a development is the normal course of events. Atomism, for example, also was first a philosophical doctrine, albeit one with a scientific aspect. The latter aspect gradually developed, slowly before the seventeenth century, rapidly thereafter.[4] Philosophy and science are both the result of one and the same original quest of knowledge. In the beginning of the rational career of man we find therefore that philosophical and scientific aspects of knowledge were strongly interwoven. Philosophical and scientific problems were still confused and not clearly distinguished. Man hardly even knew that they were distinct problems to be solved by different methods. Only in the practice of research did the necessity of differentiating methods and problems reveal itself, and only reluctantly man resigned himself to specialism in science. For this reason it is easily understood that again and again, with each new problem arising in the course of history, the different aspects were not clearly distinguished from the beginning, but had to be found while working on the problem. We have seen the same kind of development in the dispute around vitalism and mechanicism. We have seen there, too, that the solution

[4] Cf. A. G. van Melsen, *From Atomos to Atom*, Pittsburgh, 1952.

of the scientific problems does not automatically solve the philosophical issue. The solution of the former does throw important light on the latter, but the philosophical problem, whether or not a living being has a higher status, has to be considered on its own merits as a philosophical problem. Since we have considered this philosophical problem, let us examine now what light it throws on the different philosophical questions which in the past were rightly or wrongly connected with the theory of evolution.

The main question to which all other problems can be reduced is whether evolution does not reduce the appearance of higher forms of life, especially of man, to chance-events. It seems as if the driving forces of evolution are entirely blind and, consequently, everything that appears in the course of evolution would be the result of mere chance. This idea seduced many opponents of evolution to use the theory of probabilities in refutation of evolution. They argued that according to that theory the probability that a complicated organism came into existence by chance must be calculated as zero.[5] As a matter of fact, however, this kind of calculations is pure nonsense for the simple reason that we do not know enough about the natural affinities of molecules to form higher structures to have a serious basis for these calculations. The stability of a living organism demonstrates that molecules have such affinities. Therefore, if abiogenesis has taken place, chance may have played a rôle, but certainly not the most important one. The most important factor must have been the natural affinity of molecules to form higher structures in certain circumstances. Consequently, if biochemists try to trace the course which abiogenesis has taken, they think in terms of stabilities of structures, tendencies to form more complicated structures, etc.[6] In other words, they try to discover what real potencies molecules have and in what circumstances these potencies will be actualized.

By the same token if evolutionists speak about random-distribution of mutations, this does not mean that evolution is just a chance-event. For which mutations are favorable

[5] Cf. Le Comte du Noüy, *Human Destiny,* New York, 1947, III.
[6] Cf. A. I. Oparin, *The Origin of Life on the Earth,* London, 1957, (translated from the Russian).

depends upon their usefulness. The whole discussion around finality in evolution has been confused, because the analogy of the concept "finality" has been neglected.[7]

We have seen above that material activity is a kind of passive activity without self-knowledge. For this reason an evolution from molecules to macro-molecular structures and eventually to living organism is not directed toward a known aim, and in this sense there is no finality. It is, however, an evolution based upon the nature of matter, upon its immanent properties. The course the evolution actually has taken may have been arbitrary and irregular, yet the very existence of the different forms of life show how these forms are the natural results of the material potencies. Since the finality which each form of life exhibits, is based upon the inherent tendencies of its material constituents, the finality of the evolutionary process as a whole is based upon these tendencies too. Finality does not mean that an entelechy works differently from the blind potencies of matter itself, but that the mystery of life is an unfolding of the mystery of material being.

But now a new problem arises. Is it not a consequence of the line of thought we are following that man too has to be considered the product of the working of these blind tendencies? The answer has to be in the affirmative. What else should we expect? For, even apart from the theory of evolution, is it clear that all spiritual activity of man is based upon material structures. The matter-spirit problem is not easy to solve, but it is by no means a problem raised by the doctrine of evolution. The problem already existed and evolution has made it only more acute, because it has given an "historical" aspect to an old ontological problem. Some evolutionists suggested that the historical aspect solved the ontological problem, too. The mistake is obvious as we have seen. Evolution offers a possible explanation of the unity of the material world, but it does not explain that world as such, nor the hierarchy of beings in it. It should be clear that when the theory of evolution speaks of man as the product of the working of blind material forces, this thesis has to be taken in the abstract sense in which the theory of evolution considers man.

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[7] Cf. A. G. M. van Melsen, *The Philosophy of Nature*, Pittsburgh, ²1954, Ch. V.

It does not deny, therefore, the essential difference between man and the rest of nature, no more than the physico-chemical explanation of an organism denies the difference between a living organism and an inorganic thing. Evolution does not explain man, because by its physico-chemical and biological means it can never explain the spiritual in man, nor the meaning of the material universe and of its inherent tendencies. The best science can do — and this in itself is of the highest importance — is to examine what material structures condition the spiritual life. The scientist can do this, because science itself is a spiritual activity, it is part of the spiritual effort of man to understand himself. For man can never be what he is destined to be without having also a scientific knowledge of the way his spiritual activities are bound to material activities. This is the consequence of man being a spirit-in-matter. In and through matter he has to realize his self. It is well-known in medical science how sometimes bodily structures prevent man from being himself. Perhaps in the long run science will succeed in improving these structures and so open up new possibilities of spiritual life for many people who now partly or wholly are deprived from it. These possibilities throw a new light on the problem of evolution, for they show the essential difference between pre-human evolution and human evolution and as a consequence also the essential difference between man and the rest of nature. With man a new original factor appears, the spiritual, and with it a new type of finality, which takes the course of evolution in its own hand, not by neglecting the blind forces of nature, but by studying and directing them. Finality, on the human level, therefore, can be considered as the fulfilment of the inherent tendencies of matter, the unfolding of what they are meant to be. In pre-human evolution the law of the survival of the fittest is one of the driving forces. With human evolution a new law appears, the care of man for his fellow-men, especially the weak and miserable, the unfit, for with the appearance of man a kind of being came into existence in which each individual was a person. If it makes sense from the viewpoint of pre-human evolution to speak of man as the product of material forces, from the viewpoint of human evolution it makes even more sense to say that the ultimate meaning of matter should be

found in man. If we want to understand the mystery of the material world, we should look at man, for in man a little of that mystery is revealed to us.

The theory of evolution is usually considered as a degradation of the status of man. It is the purpose of this paper to stress that we can better consider it as an elevation of the status of matter, for evolution shows the meaning of its potencies and tendencies.

EVOLUTION AND THE BIBLE

by

Cyril Vollert, S.J., S.T.D.

"The ultimate end of the whole process of generation is the human soul, and to it matter tends as toward its final form."

St. Thomas Aquinas,
Contra Gentes, III, c. 22.

I. INTRODUCTION

The origin of man remains a problem. In quest of a solution, Christians and Jews turn to the first pages of the Book of Genesis. But the accounts there presented seem highly naive and full of impossible anthropomorphisms; they cannot satisfy modern scientists, for whom a universe in evolution has become a primary article in the scientific vision of reality. The vision embraces evolution of life, but also reaches out to the entire world of bodies, including the formations of the mammoth systems studied by astronomy, as well as the preparation on earth of an environment suitable for the appearance of living beings. Such a generalized view cannot well halt with lower animal species; it must seemingly extend to the origin of man himself, as a continuation on a higher plane of the evolutionary effort of life.

With the aid of the evolutionary hypothesis we are able to put into good order an immense number of facts and to acquire an excellent knowledge of the natural world. Thus science has conquered an important area of truth; by a single concept it can explain the genesis of all the living forms that have disappeared in the past, that are now in existence, and that may emerge in the future. Science can and will deepen its understanding of the evolutionary process, but does not expect that it will ever have to abandon the idea itself.

What, then, becomes of the initiative and activity of the Creator? This is a question the believer has to face. To ascertain whether the evolutionist thesis is compatible with Christian teaching, the two positions must be examined. In undertaking such a study, we must surmount a temptation that has beguiled scholars in the past. The temptation is called concordism, which is an attempt to establish a strict conformity between the Bible and positive sciences such as anthropology,

biology, and geology. A notable example is the endeavor essayed in the last century to match the six days of creation with the geological periods proposed by science. Concordism is built up on the assumption that the inspired writers were granted a scientific knowledge far in advance of their time, and that they stated in popular language what science describes in technical terms. Attempts along these lines have always failed, for the simple reason that the Bible is not a scientific text, but is a book that sets forth religious truths designed to carry us along the path toward salvation.

II. ORIGIN OF MAN IN THE BIBLE

Catholic teaching is based on revelation. As far as the origin of man is concerned, this revelation is essentially contained in two accounts presented by the first three chapters of Genesis.

A. *Some Preliminary Observations*

"In the beginning God created the heavens and the earth" (Gen. 1 : 1). Everything was made by God, and all His works are good. By His life-giving breath and the power of His word, He summoned all beings into existence. Finally, at the climax of creation, God created man to His own image, to dominate all living creatures that move on the earth. Then He fashioned the woman, who is dependent on the man but shares his dignity, as his companion and helper. These two, the man and his wife, were established in a state of innocence and happiness, and enjoyed the friendship of the Creator. From this single couple all mankind descends.

This is a rapid survey of the story that has always been important in Christian teaching. Did the author have the intention of composing the history of man's beginnings? If by history we mean a detailed record of past events, based on evidence carefully handed down in writing, we can scarcely uphold the historical character of the narrative. However, we must not evaluate the history recounted in the early chapters of Genesis according to rules imposed by the critical historical method practiced in our day. Modern historians, working on documents or examining contemporary witnesses, desire to recreate objectively the happenings of the past, to date them,

to explain them, to assign to them their proper place in universal history. Scientific history aims at an exact conformity of its narrative with the event as it actually occurred. Such a history of human origins is impossible. The two beacons of scientific history are chronology and geography. But the biblical reports of origins are not framed in any definite historical epoch or located in any definite geographical region. When was the world created? When did man appear? Where was the cradle of mankind? To such questions Genesis gives no answers. The sacred writer was far more interested in assuring us that the world exists because God drew it from nothing, that God acted personally in creating man, and that early mankind developed under the watchful eye of Providence.

Consequently the biblical accounts of creation are not historical in our modern sense of the word; they do not go back to eye-witnesses or to contemporary documents. Yet they do aspire to full truth, and are historical in the sense that they narrate past events that really happened. The creation of the universe, the formation of the first human beings, and the original state of innocence are facts; and the reporting of these facts is history. But it is a popular history, not based on written sources or on the reminiscences of people who were present when the incidents took place. The sacred author could not furnish us with accurate details, for he did not know them; even to provide a setting for his narrative he had to draw on his imagination, and he did so in line with the traditions of his time and the view of the natural world shared by all men of his era. Where the modern historian searches for the immediate causes of the facts he records and their inter-relations, the historian of Genesis perceives at every stage the direct action of God, and divine intervention marks all the decisive turning points. Hence he presents us with a religious history, in which facts are introduced, explained, and grouped for the purpose of demonstrating a religious thesis. This subordination of facts to a religious thesis does not imply an alteration, much less a falsification of facts; but it does justify simplifications, omissions, and the stressing of certain details. Thus the narration is not complete, but fragmentary; among all the facts and events of the beginnings,

the sacred historian selects those calculated to support truths that bear on the foundations of religion. He does not propose history as an end in itself, but utilizes history in view of a religious end.

The unique character of the history of origins narrated in Genesis is recognized in the encyclical, *Humani generis,* issued by Pius XII in 1950. The Holy Father points out that the early chapters of Genesis, "while properly speaking not conforming to the historical method used by the great Greek and Latin historians or by learned authors of our own day, yet pertain to the genus of history in a true sense, which exegetes have still to study and define."[1] These chapters must be considered apart. Their subject, the origins of the world and of man, belongs, not to scientific history, but to paleontology, geology, and prehistory. The Bible has nothing to do with these disciplines, and, if we should wish to compare it with the data of such sciences, we should end up with an unreal opposition or an artificial concordism. Genesis describes, in a popular way, the origin of the human race; it relates, in a simple and figurative style, such as is suitable for the mentality of a people of slight culture, basic truths underlying the economy of salvation:[2] creation by God at the beginning of time, God's special intervention in the production of the first man and woman, an original state of moral integrity and happiness, and the sin of the first parents. These truths, guaranteed by the authority of Scripture, are certain, and the facts are real. In this sense the first chapters of Genesis have a historical character.[3]

A religious idea dominates the sacred writer, and this idea he tries to convey to his readers. He had no intention of instructing us about natural history, much less about astronomy, geology, or paleontology; he teaches us, not science in the modern sense, but the arduous science of salvation. He uses the naive scientific knowledge of his time merely as means to bring out certain religious truths, to propose to his contem-

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1 *Acta Apostolicae Sedis* 42 (1950) 577.

2 See the letter of J. M. Vosté, O.P., secretary of the Pontifical Commission for Biblical Studies, to Cardinal Suhard, January 16, 1948, in *Acta Apostolicae Sedis* 40 (1948) 47.

3 R. de Vaux, O.P., *La Genèse* (Paris, 1953) 35.

poraries some events happening in the beginning in order to show forth God's omnipotence over all creation and His special providence over man, the complete dependence of man on his Creator, and man's tragic resistance to God. The story that unfolds is one of promise and salvation. Although compromised by sin, the divine plan eternally envisioned will yet be brought to success. The mighty deeds wrought by God for His people began with creation, and so the story of the origins is set at the head of the Book. But God's activity described in that Book is soteriological rather than cosmological.

To understand the teaching of the first three chapters of Genesis, which are among the most engrossing parts of the Bible, we have to know how to distinguish the religious truths that are presented from the manner in which they are proposed. In other words, we must differentiate between what the author teaches and the literary dress or literary forms he employs to express his mind. We are here confronted with a real problem. We cannot regard all the statements in these chapters as literally true; on the other hand, they are not myths. Directives toward a solution have been supplied in recent years by the great biblical encyclical, *Divino afflante Spiritu,* of Pius XII. "Let the interpreter use every care and take advantage of every suggestion provided by recent research, in an endeavor to ascertain the distinctive genius of the sacred writer, his condition in life, the age in which he lived, the written or oral sources to which he may have had recourse, and the literary forms he employed. In this way he will be able better to discover who the sacred writer was and what he meant by what he wrote. For it is clear that the supreme rule of interpretation is that which enables us to discern and declare what the author intended to say."[4]

By such directives the Holy See indicates how a grasp of difficult sections of the Bible is to be sought: exegetes are to undertake a more thorough analysis of its literary forms. In this way we may hope to determine with greater clarity and firmnes the teaching which the sacred writers meant to convey,

[4] *AAS* 35 (1943) 314. See also the letter of the Biblical Commission to Cardinal Suhard, *AAS* 40 (1948) 47.

and to apprehend the degree of historical value to be assigned to their narratives.

The Book of Genesis is the first of the five books forming the Pentateuch. Because one of the oral traditions embodied therein has its roots in the Mosaic era, and because the great Legislator stamped his genius on the work, Moses is regarded as the author of the Pentateuch. A large part of its production is due to him, and he exercised a deep influence on its ultimate form. The book was first composed in Arabia in the fifteenth or thirteenth century B.C., according to the date assigned to Moses. Later adaptations required by the changing times were made in line with the spirit of Moses and claim his authority. The final author who set down the primitive history in its definitive redaction was an anonymous Hebrew writer who probably lived during the period immediately following the Babylonian exile, in the sixth century B.C.

In his task of composition the sacred author was assisted by the divine charism of inspiration, that is, the action by which God, principal author of Scripture, utilizes men as His instruments, illuminating their minds, moving them to write, and assisting them while they write, that they may conceive clearly and express infallibly all that He wishes to communicate. The supernatural illumination of the writer's mind does not necessarily suppose that previously unknown truths were made known to him by way of revelation. Though inspiration and revelation may be given simultaneously, ordinarily they are given separately. In the latter case, intellectual enlightenment is conferred, not that the human author may be enriched with new ideas, but that he may judge with certainty the divine truth of information already acquired. Thus the inspired writer may transmit data derived from the environment in which he lives, and his work may involve recourse to oral or written sources currently available. But if, in the early chapters of Genesis, the author drew on popular stories for some of his material, as he assuredly did, he was aided by divine inspiration which kept him from all error in the choice and evaluation of such documents and traditions.

Accordingly the biblical account of our origins, written under inspiration, reports without error those truths which God wishes to have conveyed, that is, facts of the economy

of salvation which are important for all men of all ages. It also reports these truths in the way God wishes them to be expressed, by inserting them into the cultural context of the people to whom God addressed Himself directly, because it is for them first of all that His message must be available. Therefore we must distinguish the divine message, which is accessible and salutary for all men of all times and cultures, from its formulation, which is adapted to the particular environment, mentality, and customs of a people living at a definite epoch.

Although the inspired writer serves God as an instrument, he remains intelligent and free, retaining his own personality, viewpoints, and prejudices. The author of Genesis had a conception of the universe like that of his contemporaries, and spoke of natural phenomena as any of them would. He knew no more about astronomy, geology, and such sciences than other men of his generation. What he saw of the world went no farther than his eye could reach. He wrote like other men of his day and culture, and followed the common custom of composing history by weaving together all the traditions and records he could lay his hands on. He was aware that the people for whom he wrote were less interested in the historical accuracy of his narrative than in its meaning, the most significant point of any story for a Semite. All this is recalled to our attention by Pius XII in his encyclical on the promotion of biblical studies: "To express what they had in mind, the ancient Orientals did not always use the same forms and expressions as we use today; they employed those that were current among the people of their own time and place. What these were, the exegete cannot determine in advance, but only from a painstaking study of ancient literatures of the East. ... When God's words are expressed in human language, they take the form of human speech in every respect except error."[5]

The inspired writer did not invent the history of our origins. How did the incidents he narrates come to his knowledge? One simple answer is that they were directly revealed by God to Moses. But biblical scholars dislike this explanation, because the complicated character of the narratives indicates that they

[5] *Divino afflante Spiritu*, *AAS* 35 (1943) 315 f.

were compiled from previously existing sources. Until exegetes have weighed all other alternatives and found them wanting, they are unwilling to entertain the thought that an extraordinary communication of knowledge from God has fulfilled the function usually reserved for human testimony.

Another solution combines primitive revelation with subsequent tradition. It proposes that the first couple received from God a supernatural revelation about cosmic and human origins, and then handed their knowledge on to their children, who in turn transmitted in to their dispersing descendants, so that it passed from generation to generation until it eventually reached Abraham or Moses. This explanation, which found favor in a former day, was not very good even when the human race was thought to be hemmed in by a duration of a few thousand years. No objection need be raised on the score of a primitive revelation; but no such tradition could have reached the Hebrews without corruption across an interval of many thousands of generations and the hundreds of thousands of years of prehistory.

The most reasonable explanation finds its starting point in the nineteenth or eighteenth century B.C., when Abraham, with whom Israelite history begins, received from God a revelation, a promise, and a vocation. Heedful of God's summons, Abraham abandoned Mesopotamia and set out on his journey to Canaan; and he took with him his memory of Babylonian folklore about the origins of the world and of man. But God had spoken to Abraham, as later to the other patriarchs, Moses, and the prophets. Through these conversations of God with men of noble spirit, mankind came to know something of the events that happened at the beginning so far as they affect the foundations of religion. This teaching was transmitted orally and in writing, and was probably substantially completed in pre-Mosaic times, but was carried on further until the day came when an anonymous inspired author set the narratives down in the form that has become familiar to us in the Book of Genesis.

The presentation may have drawn on narratives popular among peoples who were neighbors of Israel. Under the light of inspiration, which guided his judgment in his selection of materials, the sacred writer adapted pagan notions for his

purposes, used current concepts, purged them of idolatrous and immoral elements, and exploited them as vehicles of truth. He took over much of their scenery, imagery, and idioms of speech, and forged them into an expression of truth about the true God and His creative activity.

An important factor leading to an understanding of what the sacred writer meant to convey is a comparison of the sources he employed. Before his time there were circulating in Israel two ancient traditions about the origins. Though they differ considerably in the selection of facts and their religious significance, they agree on the most basic points and form a more or less harmonious whole. Since the final author did not find to hand new documents on the history of the beginnings and did not, so far as we know, receive any fresh revelation from God about them, he limited himself to placing these two ancient traditions side by side, or rather to combining them so skillfully that, up to modern times, biblical scholars did not even suspect their existence.

One of these sources is known as the "Yahwist" tradition, because it consistently uses the name "Yahweh" as the proper name for the God of Israel. It was probably put down in writing during the reign of Solomon in the tenth century B.C. We cannot specify when it began to circulate orally, but scholars think that it took shape at the time of Moses and perhaps even earlier. Its origin is to be sought in Judea. The other tradition is called "Sacerdotal" or "Priestly," because it stems from the sacerdotal environment of the Temple in Jerusalem. The Priestly tradition is thought to have received written form during the Babylonian exile in the sixth century B.C.

The first chapter of Genesis plus the first four and a half verses of the second chapter belong to the Priestly account; the rest of the second chapter and the whole third chapter represent the more ancient Yahwist tradition. The text as it stands, not these hypothetical earlier sources, is the inspired word of God. By artistically combining the two traditions, the sacred writer sought to teach true history; but we can hardly suppose that a mind as keen and deep as his could have believed and meant to assert as historical facts certain strange elements appearing in the narrative, elements which he himself

cloaks in the veil of mystery, obscurity, and implausibility.

B. *First Account: Origin of the Universe*

The first chapter of Genesis, along with the first four and a half verses of the second chapter, incorporates a fragment of the Sacerdotal or Priestly tradition. The author chose this fragment because he saw in it a statement of fundamental truths which he regarded as the indispensable basis for the religious history he was setting out to compose. At the same time he perceived that it was a good, interesting description of the origins of the universe arranged artistically and embellished with many dramatic features likely to arouse and hold the attention of his readers.

In the beginning God created heaven and earth. At first the earth was an empty waste, shrouded in darkness; but God spoke, and light appeared. Then during a succession of six days, God uttered His creative Fiat again and again; land appeared, and so did the seas, the sun, the moon, and the stars, followed by vegetation, fish, birds, animals, and finally man, who was made in the image and likeness of God. At the close of the six days God rested, and the universe, off to a good start, set out on its long course.

This distribution of the work of creation over six days is a literary device, furnishing a popular but satisfactory framework for the classification of the various elements making up the universe as it was then known. To understand the passage we must abandon all attempt to detect in it any concordism with present scientific knowledge, for it was drawn up according to scientific notions still in infancy. Its aim is to teach, not chronology or science, but the basic truth that the universe with all its parts, and all the creatures inhabiting those parts, were made by God.

Throughout the narrative the dominant concern is religious, not scientific. Genesis has nothing to tell us about the structure of the universe or the processes of its development. The author had no thought of inquiring whether the setting he designed for his religious teaching corresponded or not with objective reality; this aspect of the question did not figure in the religious plan he had conceived, and is not connected with the purpose that induced him to write.

Nevertheless did not the author of Genesis err, and does he not lead his readers into error, at least in some of his assertions? Error is an expression of judgment contrary to the reality which a person sets out to express and which his auditors can understand. But there is no error when nothing is asserted, or when an assertion is true except from a standpoint wholly foreign to the meaning a writer intends to convey and to the expectation of the readers to whom he addresses his words. The inspired writer never intended to teach or even to insinuate anything about the intimate nature of the universe, and his readers did not expect anything of the sort from him. Of course God, if He had so willed, could have revealed the ultimate nature of the cosmos, and the human author could have passed this information along to his contemporaries. But what words could he have found? Would he have employed a scientific terminology such as is current among astronomers, chemists, and physicists of today? What could his readers have made of all this? Far from seeking to disclose the secrets of the universe and the laws which govern it, the writer limits himself to a discourse about natural phenomena as they strike the senses, in the popular language of his time.

Scientific research has not upset, and never will upset, the doctrine of the six days of creation, because the Bible moves on a plane that is utterly different from that of science. The order of events recounted in the first chapter does not correspond to reality, but is constructed on an artificial pattern which itself is influenced by scientific notions quite alien to those of our own day. Hence any quest for a chronology must issue in futility.

Not only the order, but also the manner of creation is beyond the author's scope. The problem of the origin of life is intensely interesting for us. We should like to know when and how life began. Did it burst forth spontaneously? Did a single living cell inaugurate the vital process? Did life emerge in many places at the same time or at different times and under different forms? The Bible has no answers for us. Instead, the sacred author assures us that when life began, God was there; and he asserts repeatedly that all living beings,

all the things that grow, all the fish, birds, and animals were made by God.

As for scientific theories on the origin and evolution of species, the author has not a word to say; there is not the slightest hint that he even thought of such questions. Therefore he made no pronouncement on them. He has nothing to tell us that is either favorable or unfavorable to the hypothesis of evolution. And when he comes to man, he informs us only that the first human beings were made by God.

If we read the book correctly, if we recognize the different points of view and the limited areas of competence, we perceive that there is no opposition between science and the first account of origins given in Genesis. Our endeavor should be to grasp the religious message and to mount up to its theological heights, instead of focusing our attention on the accessory, circumstantial details which the author utilized simply as apt means for placing his teaching within the reach of his fellow men.

C. *Second Account: Origin of the First Man*

A more ample description of human beginnings, independent of the cosmic narrative of the first chapter, is found in the second chapter. Its interest centers on man and his destiny, not on the formation of the universe. In language full of imagery it traces the drama of human origins and the events which profoundly affect the history of mankind. This account pertains to the Yahwist tradition. The composite name for God, "Yahweh Elohim" (Lord God) occurs only in the second and third chapters of Genesis and occasionally elsewhere. The choice of this name may have been influenced by a desire to harmonize the Yahwist tradition with the Priestly source of the first chapter, which employs only the name "Elohim" (God).

The key verse is as follows: "The Lord God molded man from the dust of the ground, and breathed into his nostrils the breath of life, and so man became a living being" (Gen. 2 : 7). In forming the first man's body, God proceeds in the way men ordinarily act when engaged at work. The earth, which previously had been arid, is watered by a spring that gushes forth, so that it becomes suitable for molding. From the mud

or clay thus formed, God takes a portion and, working like a skilled potter, molds the body of the man. In the same way, after causing the earth to produce all sorts of trees, the divine artisan molds all the beasts and birds out of the ground (Gen. 2 : 9, 19). No mention is made of created causality in the production of plants, animals, and man; the author simply prescinds from such activity, and attributes the entire causality to God.

The clay figure now receives a unique gift. God "breathed into his nostrils the breath of life." And the man begins to breathe. Although the animals are also fashioned out of the ground, Yahweh's gift of breath is mentioned only in the case of man, thus indicating his superiority. This insufflation of life-giving breath probably does not refer directly to the infusion of the human soul; Israelites of the time seem to have had no explicit notion of the spiritual nature of the soul or its function as substantial form of the body. To the mind of all ancient Orientals, life was closely associated with breathing. Life is a gift of God; and so the author, desiring to show that man owes his life to God, depicts God as breathing His own life into the man.

The name *adam*, by which the man is designated, is derived from the soil, *adamah*. If we examine the text alone, apart from context, we cannot determine whether the term *adam* (man) is collective or particular. But when we turn to the later section which speaks of the formation of Eve (Gen. 2 : 18-24), we learn that the word *adam* refers to the first man, in opposition to the first woman. Hence *adam* in the seventh verse and in the passage in which he is distinguished from the woman, seems to indicate a male individual. At any rate, when we come to the fourth and fifth chapters, *adam* becomes the proper name of the first man, Adam.

Throughout the second chapter the most disconcerting anthropomorphisms, clashing with the simple austerity of the first chapter, confront us at every turn. In the first chapter God commands; in the second He works. This rapid transition from one conception to the other clearly indicates that the author of Genesis does not mean us to take the entire narrative literally, that he introduces these anthromorphic figures as literary forms to make vivid and to support the basic lessons

he wishes to bring out. The very fact of placing the two accounts of man's creation side by side is a subtle warning that not every detail of the different descriptions is to be regarded as an assertion of objective truth.

The first chapter emphasizes God's transcendence and sovereignty. The second stresses God's providence and care for man; it does so by descending to details that mark the limit beyond which an anthromorphic depiction of God cannot well go without risking irreverence. However, once we recall the exalted Israelite conception of the Deity, we perceive that neither the author nor his readers could have taken these anthropomorphisms in a crassly literal sense.

Accordingly the seventh verse is not, in the mind of the inspired writer, historical down to its minutest details. As was quite natural in an age of ceramics, God's creative action is presented as that of a potter. The same image occurs throughout the literature of antiquity, among the Sumerians, the Babylonians, and the Egyptians, as later among the Greeks and Latins. Once the author had decided on this literary device of picturing God as a potter, he had to introduce the clay, the soft material on which potters work. His intention is not to tell us exactly how God made the first man's body, but to instruct us that the man, fragile dust of the earth, had God for his maker.

Also the second part of the verse is anthropomorphical. Under the image of God who breathes into the clay statue, the idea of the special creation of the man by God emerges. That is the paramount truth. The picture of God breathing into the nostrils of the thing that is to become man may not refer directly and explicitly to the spiritual soul as animating principle of the human body. In the sequel, however, the author shows that the man is a rational being, and so we know that he was endowed by God with a spiritual, rational soul.

The central idea in the Yahwist account is that God, unique and supreme Lord of all creation, acted directly in the production of the being who was to be lord of the earth. The man's body has a close affinity with the soil; but his life He receives from God. Exactly how God acted, we cannot determine. Certainly He did not make a figure of clay as a potter does; most assuredly He did not breathe forth a material breath

from a pair of lungs. On the other hand, the man is not represented as a product of evolutionary forces. We should be misreading the text if we placed excessive stress on the earthly origin of the man's body; the emphasis is on its divine origin. All that makes this favored being a living man comes from God. He has a special relation to the earth, it is true, for he dominates it. He also has a special relation to God, for he is made to God's image.

As seems clear, the sacred author did not intend to set down a history of man's origins chronologically arranged. Rather, he drew on existing ancient traditions familiar to him, and from them adapted some elements as literary forms to impart to simple minds a number of religious truths known ultimately from revelation.

D. *Second Account: Origin of the First Woman*

The story of human origins is interrupted by the insertion of the passage about the garden of Eden. In spite of all the rich gifts received from God and the beautiful vegetation of the garden, the man still lacked something. He was lonely. He possessed certain physical and psychological characteristics that required the companionship of another individual of his own kind. God fully understood the predicament in which the man found himself, and so, seeing that this solitude was not good, decided to create another being equal to him.

Though God was aware of the man's state of mind, He postponed creation of the desired associate by proceeding to form from the earth all the animals and birds, which He led in parade before the man that the latter might assign names to them. But sadness continued to assail the man, because he could not find among all the animals of Paradise one that was like him; not one of them met the yearnings of his heart.

God, who had created all things good, could not allow a desire that came from the man's nature to be thwarted. "The Lord God cast the man into a deep sleep and, while he slept, took one of his ribs and closed up its place with flesh. And the rib which the Lord God took from the man, He made into a woman, and brought her to him" (Gen. 2 : 21 f.).

This account of the creation of the woman has always baffled commentators and still annoys many of them. In des-

cribing the creation of the man, the Yahwist author had employed the literary image of a potter; now he introduces God as a surgeon. To spare Adam the distress which the operation would cause, God puts him into a deep sleep or coma. Then God removes one of the man's ribs, closing up the gap with flesh, and from it builds up a woman.

When the operation is finished, God brings the woman to the man. Coming out of his sleep, the man sees this being for whom he had longed and of whom, perhaps, he had dreamt. Joyfully he exclaims: "This now is bone of my bone and flesh of my flesh" — a stereotyped phrase in Hebrew which indicates the close relationship existing among members of the same kinship or tribe. The woman has a nature quite different from that of the animals. She is human like the man. The same vital spirit animates them both. The man expresses his comprehension of all this by saying that the woman is bone of his bone and flesh of his flesh.

The woman needs a name, and the man supplies it. "She shall be called woman, for from man she has been taken" (Gen. 2 : 23). In Hebrew a man or husband is called *'ish*; from this word, by popular etymology, is derived *'ishshah*, bride or wife. Later (Gen. 3 : 20) Adam called his wife Eve (mother), because she was to be the mother of all living beings that belong to the human race.

Obviously we are not meant to take all the elements of this highly anthropomorphic account in a literal sense. The most perplexing feature is the rib. We have no reason for supposing that the inspired author knew all the details about the formation of Eve's body; at any rate he uses an obscure Hebrew word, *sela'*, which can mean rib, side, flank, etc. This term does not necessarily signify that the close relationship between Adam and Eve is based on bodily derivation of the first woman from the first man. Although the text, according to its obvious sense, seems to imply that the woman's body was drawn physically from some part of the man, many modern exegetes tend to favor an interpretation in which symbolism is accorded an important place. The meaning may be that the new creature, equal in nature to the man, answers so fully to his desires that it seems as if God had extracted her from his heart; or again, that God in His work made the woman

according to the ideal image which the man had of her in his mind, or could have had.[6] Another suggestion is that Adam's body served as an exemplar cause, in the sense that the woman was fashioned according to the pattern furnished by the man.[7] In that case, Eve would be derived from Adam in the way a portrait or a statue is derived from an artist's model.

In such interpretations the incident of the rib is an apt symbol stressing the love and respect a man ought to have for his wife, seeing that God has so exquisitely proportioned her to the desires of his heart. It further explains the mutual attraction between man and woman, the close union that ought to reign between spouses, and the submission of the wife to the husband in matrimony. Woman is man's aid, his helper, at his side; she may even be said to be his side, his other half.

The proposals that have been mentioned are, of course, no more than conjectures endeavoring to apply the theory of literary forms. They do, however, seem to safeguard the truth that the origin of the woman is intimately linked, in God's intention and execution, with the origin of the man. They also eliminate some perplexities. In the supposition that Eve's body was derived physically from Adam's, we have to admit a priority of existence for the latter. How long an interval elapsed between the creation of the two? If the man lived for a time without the woman, then he, during that time, was not perfect or even wholly content, because he lacked the necessary complement of his nature, and could not exercise his destined function to be the progenitor of mankind. Moreover, the obvious sense of the text resurrects a bizarre difficulty that intrigued earlier commentators: how many ribs did Adam have at first, and how many remained after one was removed? Either before or after he was imperfect.

The entire passage about Eve heaps up anthropomorphic expressions. God reflects and deliberates. He organizes a procession of animals before Adam. He notices that Adam cannot find in the animal world a being of his own nature. Like a good surgeon, He puts the man to sleep. He extracts a rib. He uses the rib as a core around which to construct the

[6] L. Arnaldich, O.F.M., *El origen del mundo y del hombre según la Biblia* (Madrid, 1957) 120.

[7] H. Lusseau, *Précis d'histoire biblique* (Paris, 1949) 55 f.

woman. He fills up with flesh the gap left by the excision of the rib. He takes the woman by the hand and brings her to Adam. The whole chapter moves on a plane of imagery. God molds the clay, breathes forth His breath, extracts a rib, builds up a body around it. All these verbs involve imagery; is not the same true of the nouns that are the objects of the verbs? The dust of the earth stands for the material element in man. Likewise the rib seems to symbolize the woman's human nature, for she has her nature in dependence on the man. The central fact conveyed by the account, at every stage of which a striking picture fascinates the unsophisticated reader or hearer, seems to come to this: once God had created the male, He had to create the female. For the man's existence, God had intervened with a special action; in the same way He intervened in the creation of the other being who was to be the man's associate. Perfect counterpart of the man, she becomes truly his aid by her union with him in marriage. This equality in nature, which was not appreciated in the ancient Orient, even in Israel where woman was held to be inferior to man, is thus clearly acknowledged.

What is important in the biblical account is not the manner of Eve's creation, but the doctrinal teaching. The circumstances of the narrative are to be regarded as literary dressing and symbolic setting, without corresponding to objective historical reality.

This interpretation of the text seems to be in line with the wise rules of exegesis issued by the Holy See these latter years. Pius XII in *Divino afflante Spiritu* encourages biblical scholars to seek new ways of discovering the sacred author's meaning. And he reminds them that they have freedom of investigation in all matters that have not been defined by the Church. The encyclical goes on to state that there are very few texts in the Bible whose sense has been authentically declared by the Church, and very few which the Fathers explain unanimously or propose as pertaining to faith.[8] In the present stage of biblical science it is scarcely possible to arrive at a certain solution of all the problems raised by the early chapters of Genesis, but some success has been achieved

[8] *AAS* 35 (1943) 319.

in distinguishing the intended literal sense from artificial embellishments. The interpretation that has been outlined is now shared by most Catholic commentators.[9]

At first sight, several passages in St. Paul seem opposed to this interpretation. Man "is the image and glory of God. But woman is the glory of man. For man is not from woman, but woman from man. For man was not created for woman, but woman for man" (I Cor. 11 : 7-9). Paul's purpose, however, is not to explain authentically the Genesis text to which he alludes, but simply to bring out the man's superiority; in the divine plan of creation the woman's existence is required by the man. Similarly, I Tim. 2 : 13 gives the reason why a woman should not exercise authority over a man: "For Adam was formed first, then Eve." St. Paul is not necessarily referring to temporal priority. The description of the woman's formation in Genesis is designed to teach that in the family the husband and father is the head by nature and divine appointment, and that all the other members of the family are subject to him, since in any society good order demands central authority.

The typology so beloved by many Fathers, who saw in the formation of Eve from Adam's rib a figure of the Church formed from the side of Christ, holds good even if the incident is regarded as a literary form. That patristic testimony may command our assent, the Fathers must exhibit unanimous accord about the interpretation of a text, and must propose their interpretation as a truth of faith or as necessarily connected with such a truth. These conditions are lacking in the present case.[10]

No documents issued by the official teaching authority of the Church definitively declare the meaning of our text. In 1909 a response of the Biblical Commission in Rome, while authorizing abandonment of the literal interpretation and a search for the real meaning intended by the inspired writer, insisted that the historical sense must be retained with regard

[9] Among dozens of others, see J. Chaine, *Le livre de la Genèse* (Paris, 1949) 40; M. Grison, *Problèmes d'origines* (Paris, 1954) 260, n. 24; C. Hauret, *Beginnings: Genesis and Modern Science* (Dubuque, 1955) 114—19, 123; L. Arnaldich, *El origen del mundo y del hombre según la Biblia* (Madrid, 1957) 117, 124 f., 132.

[10] On patristic explanations of Genesis, see Pius XII in *Divino afflante Spiritu*, *AAS* 35 (1943) 313.

to certain facts touching on the foundations of the Christian religion. Among these facts are "the special creation of man; the formation of the first woman from the first man; the unity of the human race."[11] The words were carefully chosen. The Commission does not say, "immediate creation of the body of the first man," but only "special creation of man." It says, "formation of the first woman from the first man," but not "from the body of the first man," and passes the "rib" over in complete silence. This seems to be a sufficient invitation to avoid stark realism. These decrees do not close the door to further study, as was pointed out by J. M. Vosté, secretary of the Biblical Commission, in a letter to Cardinal Suhard of Paris in 1948: "If the three official responses issued by the Biblical Commission are understood and interpreted in the light of the Supreme Pontiff's recommendation[12] ... these replies by no means block the way to a further, truly scientific investigation of these problems, in accord with the findings of the past forty years. Consequently the Biblical Commission does not think that there is need, ot least for the present, to promulgate new decrees on these questions."[13]

Taking advantage of the latitude extended by such directives, Catholic commentators have felt free to propose new interpretations. Great advances have been made in biblical criticism, particularly in the matter of literary forms employed in the Bible. Because of this progress, the Commission itself judged that it was unnecessary, "at least for the present," to grant the requests of scholars who desired the abrogation of the earlier decrees.

Also an allocution of Pius XII to the Pontifical Academy of Sciences in 1941 leaves the door open to further discussions

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[11] H. Denzinger, *Enchiridion Symbolorum,* nos. 2121—2128, especially no. 2123.

[12] The reference is to *Divino afflante Spiritu, AAS* 35 (1943) 319, in which the Pope states that "there is no reason why the Catholic exegete, animated by an active and ardent love of his subject and sincerely devoted to Holy Mother Church, should in any way be deterred from coming to grips again and again with difficult questions that have not yet been fully solved." Pius XII adds that "all should abhor that intemperate zeal which judges that whatever is new should for that very reason be resisted or viewed with suspicion."

[13] *AAS* 40 (1948) 46.

about the origins of the human body. With reference to Eve, the Pope said: "Only from a man could there proceed another man who would call him father and progenitor; and the helper given by God to the first man comes from him and is flesh of his flesh, formed to be his companion; she receives her name from the man, because she was derived from him."[14] The Holy Father is scarcely more specific than Genesis. He is intent on making the point that man and woman are essentially superior to animals; neither Adam nor Eve had an animal as "father and progenitor." Since the Pope confines himself to indefinite expressions, he does not here intend, apparently, to settle the question whether a bodily extraction actually occured.[15]

In the encyclical *Humani generis* of 1950 the Holy Father expressly teaches that the direct creation of the human soul by God pertains to Catholic faith, but states that discussion of the origin of the human body may continue among competent scholars.[16] The document does not distinguish between the body of Adam and that of Eve, and therefore, we may judge, does not limit the discussion to the body of the first man.

E. *The Bible and Evolution*

The principle of evolution is so widely accepted that scientific thinking is thoroughly dominated by it. In response to scientific stimulus, some exegetes have tried to show that evolution is favored by Genesis 2 : 7: "The Lord God molded man from the dust of the ground, and breathed into his nostrils the breath of life, and so man became a living being." Since the last phrase can be correctly translated: "man became a living person," the entire verse is rendered: "A living organism, animated by a spiritual soul which God created, became a living person." Before becoming a man, the matter used by the Creator would already have been a living organism. Therefore the Bible may well teach evolution of the human body.

[14] *AAS* 33 (1941) 506.
[15] Thus C. Hauret, *Beginnings: Genesis and Modern Science* (Dubuque, 1955) 118 f.; L. Arnaldich, *El origen del mundo y del hombre según la Biblia* (Madrid, 1957) 130.
[16] *AAS* 42 (1950) 575 f.

This attempt at concordism is doomed to frustration. Just as the first chapter of Genesis does not approach the problem of the origins of the universe from a background of astronomy and geology, so the second chapter does not approach the problem of human origins from a background of scientific evolution. The first man's body, which could have been created by God from nothing or could have been formed from the dust of the earth, could also have been prepared throughout millions of years by a long, slow process of evolution. God could have directed such a process until the day, appointed in His eternal wisdom, when a spiritual soul which makes man what he is would be bestowed on a body thus made ready for it by secondary causes. The fact is, however, that Genesis tells us, not how man was created, but what he is by creation. The real doctrinal content is found in the truths about man's nature and his relationship with God and the world. The literary form of the narrative is a dramatization of these truths.

The verse adduced above in favor of evolution has also been used against the theory. We are told that "man became a living being." Hence we may reason that before God breathed forth His life-giving breath, the recipient of that breath was not alive; but it would have been alive in the supposition that God infused a human soul into the body of an animal. To tell the truth, all that we need to conclude is that the divine breath imparted something which animals lack. The exegete cannot decide from this text whether the material used by God to fashion the first man's body was living or lifeless, organic or inorganic. The only inference he can draw is that the substance marked out to be the body of Adam was not a human body until a rational soul animated it. Whatever it may have been before, it became a man's body when it received a man's soul.

All endeavors either to commend or to repudiate evolution from the Bible come to nothing. The author of Genesis never raises the problem of the exact manner in which the human body was formed, and he certainly had no knowledge of scientific evolution. He stresses the fact that God exercised some special action in the creation of the first representatives of mankind and that they have a nature and a destiny which

they share with no other creatures. Consequently, while he is not a source of scientific information, he has something to say about the beginnings of the race that does not fall under scientific observation.

As far as the Bible is concerned, evolution may have played its part in the formation of the body into which God infused a human spirit. God, when creating Adam and Eve, could have utilized organic matter already living. Whether He did so or not, is a question that pertains, not to exegesis, but to sciences such as anthropology, biology, and paleontology. Sacred Scripture neither teaches nor rejects evolution; it observes strict neutrality.

The same may be said of the Fathers, who simply repeat what Scripture teaches. There is not a single patristic text that may be alleged to support an evolutionist explanation of human origins; on the other hand, there are no explicit texts that oppose it from a theological point of view.[17]

III. SOME ZONES OF OBSCURITY OR DISCORD

Theories of theistic, finalistic evolution, even as extending to man's body, are quite acceptable in Catholic circles. The notion that God could have employed a long series of secondary causes, operating according to fixed laws, eventually to produce a body capable of being animated by a spiritual soul, involves nothing incongruous. Theologians in increasing numbers perceive that it is quite fitting for the Creator, if He so elected, to have used for such a purpose the highest form of living matter, that of an anthropoid morphologically closest to man, rather than lifeless dust. The process of evolution, in this supposition, would have been designed by the Creator expressly to lead to, and issue in, the formation of the human body.

A. *Adaptation of the Body*

Some theologians add that God would have had to exercise a direct action on the organism, either of an adult animal or in the initial embryonic stage, to cause the ultimate disposition

[17] Cf. E. González, "El evolucionismo en los Santos Padres," in *El evolucionismo en filosofía y en teología* (Barcelona, 1956) 155–81.

which would adapt the living being for the reception of a spiritual soul. The necessity of such intervention is maintained either for philosophical reasons[18] or to preserve conformity with a decree of the Biblical Commission of 1909, which mentions the special creation of man, not only of his soul.[19] Such a modification could have been effected at the very instant the soul was infused into the body. Certainly the spiritual soul would radically transform the pre-existing animal organism it began to animate, for the operations of sense are specifically different and nobler in man than in animals.[20] Other Catholic authors make no reference to such an intervention as distinct from the ordinary laws of divine providence, or think that it was not needed, since the primitive organism was endowed by God with a definite capacity and perfectibility, and from the very beginning, through an evolutionary process willed and supervised by God, tended in the direction of the human body.

Whatever may be the merits of the philosophical arguments postulating such direct activity on God's part, Scripture and theology seem to have no voice in the debate. Furthermore, the Biblical Commission refers to man, not to man's body, and states that the creation of man was special, not immediate. An evolutionary explanation of human origins that preserves awareness of the essential difference between the highest animal and man, who possesses the intelligence that makes him God's image, runs afoul of no Christian dogma, so long as it recognizes the creation of man's spiritual soul by God.

B. *Continuity and Discontinuity*

At this point a discordant note faintly sounds to disturb the harmony existing between the religious and scientific attitudes. Science thinks of a continuity that took place, in insensible gradations of transition, from a purely animal state to a human state. Such biological continuity of man with the higher

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[18] Cf. M. M. Labourdette, O.P., *Le péché originel et les origines de l'homme* (Paris, 1953) 126 f.; H. Lusseau, *Précis d'histoire biblique* (Paris, 1949) 50, 55, 66.

[19] Cf. F. Ceuppens, O.P., *Genèse I-III* (Bruges, n.d.) 121; J. de Aldama, S.J., "El evolucionismo antropológico ante el magisterio de la Iglesia," in *El evolucionismo en filosofía y en teología* (Barcelona, 1956) 241 f.

[20] St. Thomas Aquinas, *De potentia*, q. 3, a. 11 ad 1.

animals is regarded as securely established; a host of structural similarities, which are particularly notable in the skeletal remains of primitive men, leaves no room for doubt in the scientist's mind. Man entered the world of living creatures without the slightest noise.

On the other hand, faith asserts a gap between animal nature and human nature. The latter, in that which makes the nature specifically human, is spiritual, dedicated to immortality, and capable of personal friendship with God. Hence we are faced with two alternatives. One of them breaks the continuity of the upward movement of life in the universe. In this hypothesis we interpret the poetry of the biblical image to mean that man's body was formed from pre-existent, lifeless matter; like a sculptor, God fashioned a statue from the earth, and then immediately and completely transformed it by infusing into it a spiritual soul. The other alternative, which acknowledges the ascensional biological movement of the cosmos, represents the human body as derived from a pre-existent but highly evolved organism. Yet something entirely new is produced, the spiritual, immortal soul, which can come into being only by way of creation from nothing. It is made for union with a body, but surpasses the whole order of bodily causality. This spiritual soul introduces a profound ontological discontinuity into the series of continuities with which science is concerned; because of it, the body of the first human being, even if it resulted from the infusion of a soul into a pre-ordained animal organism, was, metaphysically speaking, an absolute beginning, and was caused by God alone.

The situation seems rather embarassing. Science asserts a real continuity; theology asserts a definite cleavage, beginning with a definite individual known as Adam, who really existed, even though we are unable to identify him historically. If we insist on confronting the two positions with each other on the same plane, the scientific view and the religious view of human origins must appear incompatible.

However, the incompatibility is only superficial. If we distinguish clearly the object of each and the limitations which each must impose on itself to state its case legitimately, the two assertions are perfectly reconcilable. Science thinks of an observable continuity. This kind of continuity does not at all

disconcert the religious teaching that the human being is animated by a spiritual soul. The observable continuity joining an animal line to the human stock may be illustrated by an analogous continuity, likewise observable, which joins the human infant to the parental line. Catholic theology insists that the human soul does not proceed by way of generation from the human parents, but is directly created by God and infused into the living organism for which the parents are responsible. Nevertheless, even though the soul is not derived from the parental line, observable continuity is not disrupted. Therefore the direct creation of the soul by God accords perfectly with the natural processes in which nothing prevents us from maintaining continuity, in the one case between man and man, in the other between animal and man. The gap which theology introduces affects a level of being quite other than that of the biological organism. Consequently the ontological discontinuity which faith requires, and the morphological continuity to which science rallies, are simultaneously realizable.[21]

The solution may be brought out in a somewhat different way. Scientists apply the term "mutations" to brusque variations that modify the genotype and become hereditary. Is not the natural course of events violated by the sudden appearance of a being endowed with a spiritual soul created by God? In reply we may consider that elevation from the animal to the human level can be represented in two ways. God may have chosen an adult pair of anthropoids and infused spiritual souls into them; in this case the law regulating biological mutations is not applicable, but is simply surpassed. Or else we may imagine that the first two human souls were infused into germ cells; then the law regulating mutations is not transgressed in a manner that is biologically ascertainable; apparent biological continuity is safeguarded, in spite of the enormous metaphysical discontinuity between a brute animal and a rational animal; it is only later, after a dormant period of some years, that awakening to the life of reason would occur.[22] In either

[21] Cf. D. Dubarle, O.P., "Evolution et évolutionnisme," *Lumière et Vie* 34 (1957) 86.

[22] Cf. C. Journet, "La question des origines: la Bible et les sciences," *Nova et Vetera* 33 (1958) 175.

case, the scientist on his experimental plane notes a mutation, a new threshold crossed by life in its continuous ascent. But on the ontological plane the theologian and the philosopher discern the creative action of God.

C. *Adult or Embryo?*

These considerations open up a new aspect of the problem. We all acknowledge that God could have used matter already existing and living to form the body of the first men, and that thus a line of physical descent would relate man to the animal world. But when we try to envision the situation in the concrete, we find ourselves enmeshed in perplexity. If we admit that God transformed an adult organism into man, we are entertaining a hypothesis that preserves only a tenuous connection with any theory of evolution. On the other hand, if we maintain that the change was effected in the embryonic state, we find it hard to imagine the first men living their infant life in the midst of brute animals.

We may suppose that when a certain anthropoid family arrived by evolution at a suitable stage of morphological and cerebral perfection, God caused to come forth from that family the first human infant or a pair of infants. Since even apes and monkeys have a highly developed maternal sentiment, we may further conjecture that such a sentiment was enhanced in our anthropoid group. Then, after a period of necessary rearing and growth, the human boy and girl may have separated from the horde and set out to lead a free life. However, if we wish to avoid a superficial simplicity, we must confess that we are faced with a problem that has not received an adequate solution. Appeal to the Bible will do no good. The author of Genesis supplies no answer, for no question of the first men's biological descent ever crossed his mind.

D. *Paradise Man and Primitive Man*

Possibly a greater problem, and one for which, certainly, a facile solution is not available, arises from the state of perfection in which, according to theology, the first human beings lived in the beginning.

Between the biblical accounts of the creation of the man and woman is inserted the passage about Paradise. "The Lord

God planted a garden in Eden, to the east, and He put there the man He had formed" (Gen. 2 : 8). The term "garden" is translated "paradise" in Greek and other languages, after a Persian word meaning a park set aside for hunting and pleasure. It is depicted in Genesis as a sort of oasis in the oriental desert.

The man was installed in the garden to tend and cultivate it; but this work of cultivation was not the hard, sweaty labor that would be imposed after his sin. He exercises dominion over the animals, to which he assigns names suitable to their natures. He has a conscience that enables him to distinguish between good and evil. He understands the extent of the command laid on him and the disastrous consequences of disobedience to God.

The state of Paradise is aptly called "original justice" in theology. The term stresses moral perfection; our first parents were "just," that is, according to the biblical meaning of the word, they were submissive to God as children are to a beloved father. Eden, the garden of pleasure where they were to lead a happy life, comes to them from God's love, which raised them from the level of creatures to that of sons. Therefore the gift which properly established Adam and Eve in the condition of original justice was sanctifying grace. In Genesis this is merely hinted at in the description of the stupendous familiarity the first couple had with God, and is brought out more clearly in the New Testament. The immediate fruit of their fullness of grace was an easy control over passion. This gift of "integrity," or absence of conflict between sense craving and the nobler desires of the spirit, is indicated ingenuously in the statement that they were both naked yet had no shame. The spontaneity of their affective life was in no way jeopardized, but their tendency toward higher good was not retarded by inordinate attraction to sense goods.

Another gift the first couple received for themselves and their posterity was bodily immortality. Genesis mentions the tree of life, access to which was cut off after sin. The punishment inflicted on Adam shows, as St. Paul says (Rom. 5 : 12), that death was introduced into the world by his disobedience. How God would have preserved men in immortality we are not told.

We can readily understand how the possession of such gifts made the life of Adam and Eve very happy. Without anguish of the terror of death, without obstacles to good activity raised by passions, in intimate friendship with God their Father, they inhabited a beautiful estate and began to achieve mastery over material creation, free of the burden of fatiguing labor.

This teaching about the original perfection of mankind presents today a serious challenge. How are we to reconcile the data of revelation on the dignity of the first men with the data of paleontology attesting that the farther back we go into the past, the more the life of the human being, as borne out by the traits of his fossil remains, approaches animality? Although researches into prehistory are far from having furnished us with a complete and sure picture of primitive man, the results which have accumulated not only ignore a paradisiacal state of mankind at its beginnings, but seem to exclude it by what they have disclosed about the less than rudimentary culture of primitive men. The man discovered by the sciences of prehistory hardly resembles the man of the earthly Paradise. On the one side, we have a being presented as perfect; on the other, a being close to the beasts, advancing toward a more human condition by painful conquests of himself and his environment. The idea of a Fall from a level of perfection possessed from the outset yields to the idea of a level toward which to struggle in the future. Perfection is to be found, not at the beginning of the road, but at the end. These two points of view on human origins are hard to harmonize, and the more the scientific description of early man gains in clarity, the more the picture painted by revelation tends to vanish toward folklore.

To tell the truth, the man exhibited by the author of Genesis is not the primitive man of Java or Peking, but a man of his own time and nation, transported to an idealized version of a garden bearing topographical features of an oasis in his own country. Contemporary theology is well aware of this situation, and is eager to trace out a solution.

In the first place, we must observe that the two kinds of knowledge we possess about human origins are not located on the same plane. Prehistory and paleontology move on the

empirical plane; they open to us a natural history of man. Revelation is situated on the spiritual plane, and teaches the supernatural history of man. We do not have to choose between the revealed notion and the scientific notion. Both can be true, each in its own order. In any case, the first cannot be either verified or contradicted by the second, for the realities it expresses cannot be ascertained by historical research. The state of original justice can in no way be likened to a cultural cycle that leaves traces for paleontologists to discover.

Nevertheless scientific progress and the evolutionist outlook dominating the modern mind have urgently invited theologians to reconsider the classical depiction of the life of Adam and Eve in Paradise, and especially to distinguish the genuine word of God from incrustations that may have been introduced by human interpretations. It is undeniable that theologians of an earlier day often exaggerated the privileges of Adam and Eve, describing in detail what would have been the history of mankind if Adam had not sinned. A clearer grasp of the purpose of revelation has tended to call a halt to speculations that are more interesting than useful. Contemporary exegetes are more accurate than their predecessors in fixing the essential elements of original justice as required by faith.

How does Genesis display the original state that was forfeited by sin? The description is characterized by a tone of sober reserve.[23] In the miniature society formed by the first pair a perfect harmony prevails, indicated by their nakedness. "Both the man and his wife were naked, but they felt no shame" (Gen. 2:25). Man and woman, at peace with God, are at peace with each other and have nothing to hide. This feature illustrates their moral condition and their mutual trust and esteem. The nakedness of Eden supposes both the clemency of external nature and a relationship between human persons undisturbed by fear and confusion. Among the beautiful fruit and shade trees planted in the garden, the tree of life (Gen. 2:9) symbolizes the immortality man would have enjoyed if he had persevered in fidelity to God. The author's main purpose is to set forth the situation that followed the

[23] Cf. A. M. Dubarle, O.P., "Original Sin in Genesis," *Downside Review* 76 (1958) 239.

transgression; he makes us feel its pain, but merely hints at what preceded it. The sharpest contrast is between nakedness unembarrassed and nakedness ashamed. The account suggests other differences, but does not clearly define them. It intimates that work was not slavery, but makes no explicit statement. One detail indicates that the original creation inaugurated a cultural development to follow later: technical and artistic inventions do not appear until subsequent generations at several removes from Adam and Eve (Gen. 4 : 20-22).

In this brief sketch we are provided with very little material for compiling a description of the primitive condition of the first human beings. Yet it enables us to perceive the Creator's providence and love, to which, on man's part, an untroubled and fearless access to God corresponds. The account of Paradise is a highly serious history, set forth in artistic fashion, in a simple and figurative style. Paradise symbolizes, in an ingenuous way, the well-being of the state of grace as the normal condition of man in relation to God, and the only one that truly measures up to the Creator's designs.

Medieval scholastics unquestionably overstated the perfection of Adam's knowledge. According to the inspired text, Adam assigned names to the animals, which implies intelligence, and both he and his wife understood God's command. But the development of arts and crafts was left to future ages, and we have no reason to suspect that later men merely rediscovered what the first pair had possessed from the beginning. The religious and moral perfection of Paradise was high, because it was supernatural; but the cultural level of life in the Garden could have been very elementary.

In grappling with this problem, we may not overlook the change which original sin wrought in man himself and in his conditions of life. Researches made into prehistory, when they bring us a knowledge of fossil remains of Adam's descendants or of their primitive tools, have to do with men fallen from their first estate. The earthly Paradise was forsaken for the valley of tears. Mankind, cast out of Eden and no longer enjoying special privileges, had to face the formidable task of dominating hostile nature, even for the bare necessities required for survival. Small wonder if mankind had to go through a period of hesitation and groping, and if its march forward was

not always triumphant or even constant, but was thwarted by setbacks and descents toward the borders of animality, with biological slips and anatomical relapses. If such were the case, animal traits observed in fossil men might be the results of recessive mutations.

Another fact we must not overlook is that we know but a feeble part of existing fossils. The crust of the earth still hides many a secret. Present hypotheses skip over vast spaces empty of data. Readjustments called for by new discoveries are inevitable, and will surely advance our knowledge of earliest mankind.

These are only hints and hypotheses. At least they afford us a glimpse of a possibility of harmonizing Catholic faith with the sciences of prehistory. The believer can well accord to science that Adam, ancestor of the race *homo sapiens,* may have been morphologically and culturally a primitive — but a primitive to whom God communicated knowledge adequate for his condition in life and capable of being directed toward his supernatural end. Adam's preternatural gifts can readily be reconciled with the data of prehistory and ethnology. The evolutionist perspective does not seem to involve any essential change in the doctrine of man's original state.

E. *Monogenism* or *Polygenism*

Contemporary anthropology is predominantly in favor of monophyletism, understanding by this word the connection of all mankind with one and the same original line or stock. By their morphological, physiological, and psychical traits, all men exhibit themselves as members of a single great family that has had a wide history and has divided and subdivided repeatedly. The term "monogenism" is often employed by scientists to express such unity of stock, although the question whether this stock was made up of one or many original couples is left undetermined.

However, if anthropologists can trace the various ethnic groups to a single primitive stock, paleontology and biology cannot furnish data either to favor or to oppose a strict monogenism, in the sense of a single pair standing at the head of the human species. Man, who entered the world without noise, afterward walked so quietly that whenever science can

catch sight of him as disclosed by his fossil skeleton or his stone tools, he already lives with others of his kind in bands and covers the ancient earth.

When, therefore, revelation exhibits a first human individual or a first human couple, it proposes a fact which science is incapable either of controlling or weakening. Consequently the existence of a first man or a first pair inaugurating the human race cannot be thought of as incompatible with what science is in a position to establish about human origins. From the scientific point of view, Adam is simply a hypothesis that is admissible but unverifiable.[24] Science does, indeed, tend to think that passage from animal to man occured but once in the history of the earth, without being repeated at various times in the midst of several anthropoid branches. But this monogenism is not the monogenism of theology. By monogenism, theology means a single original couple, whereas the paleontological sciences cannot specify more than the unity of a population that might comprise many males and females.

Accordingly the question whether a single first man and woman marked the commencement of humankind is beyond the frontiers at which science can arrive. But on this problem we have the testimony of the Bible that Adam and Eve were the first man and woman, and that from them proceeded, by way of generation, all the human beings who after them have dwelt on the earth.

In the first chapter of Genesis this teaching is contained implicitly in God's order to the first man and woman to multiply and fill the earth. It is manifested more clearly in the second chapter, where God creates the woman to implement His plans for the race. An unbiased reading of the text leads to the conclusion that all men who people the planet are descendants of the first pair. Moreover, Eve is represented as the mother of all the living (Gen. 3 : 20). But it is especially the doctrine of original sin that requires the unity of the human race; St. Paul affirms that Adam's sin and its punishment, death, are passed along to all men (Rom. 5 : 12). The trans-

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[24] Cf. D. Dubarle, O.P., "Evolution et évolutionnisme," *Lumière et Vie* 34 (1957) 87 f.

mission of this sin and its punishment cannot be explained except by descent.

Such is the teaching of *Humani generis*.[25] Pius XII states that polygenism is incompatible with the dogma of original sin. The supposition of a collective Adam is untenable because it is out of joint with what the sources of revelation and the acts of the magisterium of the Church proclaim about original sin, which stems from a sin truly committed by an individual person, Adam. This declaration of the Holy Father decides the question and closes discussions, formerly engaged in by some theologians, on the reconciliation of the polygenist hypothesis with faith.

Hence this document asserts monogenism. It does not, however, affirm that monogenism is directly taught by the sources of revelation, but uses an indirect argument. It appeals to the dogma of original sin considered in all its elements: the universality of the state of sin in which all men existing on earth after Adam are conceived, the transmission of the sin by generation, and its origin from a sin really committed by Adam. Only monogenism is conformable with the data of revelation on original sin as expressed by St. Paul and precisely formulated by the Council of Trent.[26]

Thus Pius XII dissociates the questions of evolution and polygenism. The plurality of human origins postulated by some evolutionists is based on purely theoretical grounds; but the faithful have sufficient reasons for maintaining monogenism, even in an evolutionist perspective. The decision to join for the first time the creation and infusion of the spiritual soul with the emergence of a high degree of zoological perfection arrived at in the ascensional movement of evolution, can come only from God. The interplay of biological laws is radically incapable of determining the advent of the immortal soul, which by its nature transcends the entire mechanism of the universe. Only an evolution divinely directed can account for the accession of an animal cell to human dignity.[27] Con-

[25] *AAS* 42 (1950) 576.
[26] Rom. 5 : 12—19; Council of Trent, sess. V, can. 1—4 (Denz., 788—791).
[27] Cf. C. Journet, "La question des origines: la Bible et les sciences," *Nova et Vetera* 33 (1958) 175.

sequently it is not astonishing that such an evolution should have issued in a single human couple.

Hence we are wholly reasonable if we conclude that monogenism, which *Humani generis* teaches on the basis of revelation, is not against, but only beyond science. It does not in any way preclude the evolutionist vision of the formation of the first human beings.

IV. CONCLUSIONS

Yet areas of uncertainty remain, and the Church is aware of them. The encyclical *Humani generis* of 1950 repeats what Pius XII had said in 1941, that the derivation of man's body from organic matter has not yet been completely proved. Hence no one should speak as though it were a demonstrated fact, and no one should proceed as though the sources of revelation did not caution prudence and moderation in this question.[28]

The previous attitude of the Holy See, about a generation ago, is illustrated by a report emanating from a trustworthy theologian in Rome and printed in a Catholic periodical. In resistance to pressure brought to bear on him to express disapproval of anthropological evolution, Pius XI is said to have replied: "We must not close a door which perhaps we should have to open again. In the history of the Church, one Galileo case is enough."[29] Progress has accelerated since that day. On February 28, 1959, the New York *Times* carried a story about a lecture on evolution delivered at the University of Rome, with Eugene Cardinal Tisserant in attendance. A paragraph from the account may be quoted: "Scientists here who had been consulted by the Vatican in recent days said they had gained the impression that its [the Vatican's] appraisal of the evolutionary theory was going 'far beyond' the positions laid down in the encyclical 'Humani Generis.'" These, to be sure, are only reports, and names are not named. There seems to be little reason to quarrel with their credibility.

In any case, contemporary scientific advance cannot, or at least should not, engender in the Christian either disquiet or

[28] *AAS* 42 (1950) 562, 575 f.

[29] C. Colombo, "Trasformismo antropologico e teologia," *La Scuola Cattolica* 77 (1949) 20 n.

alarm. The Christian is sure that science and faith cannot contradict each other. The world and everything in it is God's. The God of nature is also the God of revelation. God's manifestation of Himself in revelation vastly surpasses His self-manifestation in creation, but does not oppose it. In the problem of human origins frictions and even clashes perhaps had to develop between science and religion. But this tense situation — if there still is tension — relaxes in the measure in which each avoids encroaching on the domain of the other. On some points we are not yet able to perceive a positive accord between theology and science; but the recognition that there is no discord is a tremendous gain. More important than forcibly premature solutions is the intellectual attitude we all ought to make our own, an attitude arising out of intellectual open-mindedness and honesty, of reception of every authentic truth no matter whence it originates, as well as of filial submissiveness to the guidance of the teaching authority of the Church that is assisted by the Holy Spirit.[30]

The experience of the past begets confidence for the future. Occasions for misunderstandings and apparent conflicts between science and religion have steadily decreased. Many of the old issues have become musty museum curios. New ones will perhaps take their place. Scientists, philosophers, and theologians must come to one another's aid in an endeavor to master such problems in areas that are common to all of them. In this enterprise they are partners and collaborators, not adversaries or competitors — just as evolution itself is not in competition with creation, for creation is dependence on God, and evolution does not alter this basic relationship.

Certainly the thought of an evolution of organisms is rich in sublimity, and Charles Darwin expressed his appreciation of this fact in the closing lines of his *Origin of Species*: "There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, while this planet has gone cycling on according to the fixed laws of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been and are being evolved." Whether an evolution on

[30] Cf. C. Baumgartner, "Bulletin de théologie dogmatique," *Recherches de Science Religieuse* 46 (1958) 577.

this colossal scale has taken place, an evolution which eventually culminated in the bodily form of man, the Book of Genesis is unable to say. Nor is theology in a position to instruct us about the matter, because the objects of natural science are beyond its scope and competence. For an exact exposition we must look to scientific investigation; biology, comparative anatomy, genetics, geology, paleontology, anthropology, and their sister sciences have the task of discovering and displaying the evidence. If science is able to prove evolution as the certain product of its researches and to make known its underlying causes, no difficulty arises from Christian faith.[31] On the contrary, the faith welcomes so lofty and inspiring a view of the universe, in which the whole powerful striving and the tenacious reaching out, in countless new attempts over the span of immense ages, were an astonishing and marvelous preparation for the coming of man.

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[31] Cf. P. Overhage, S.J., "Evolution der Organismen und christlicher Glaube," *Stimmen der Zeit* 161 (1958) 290 f.

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